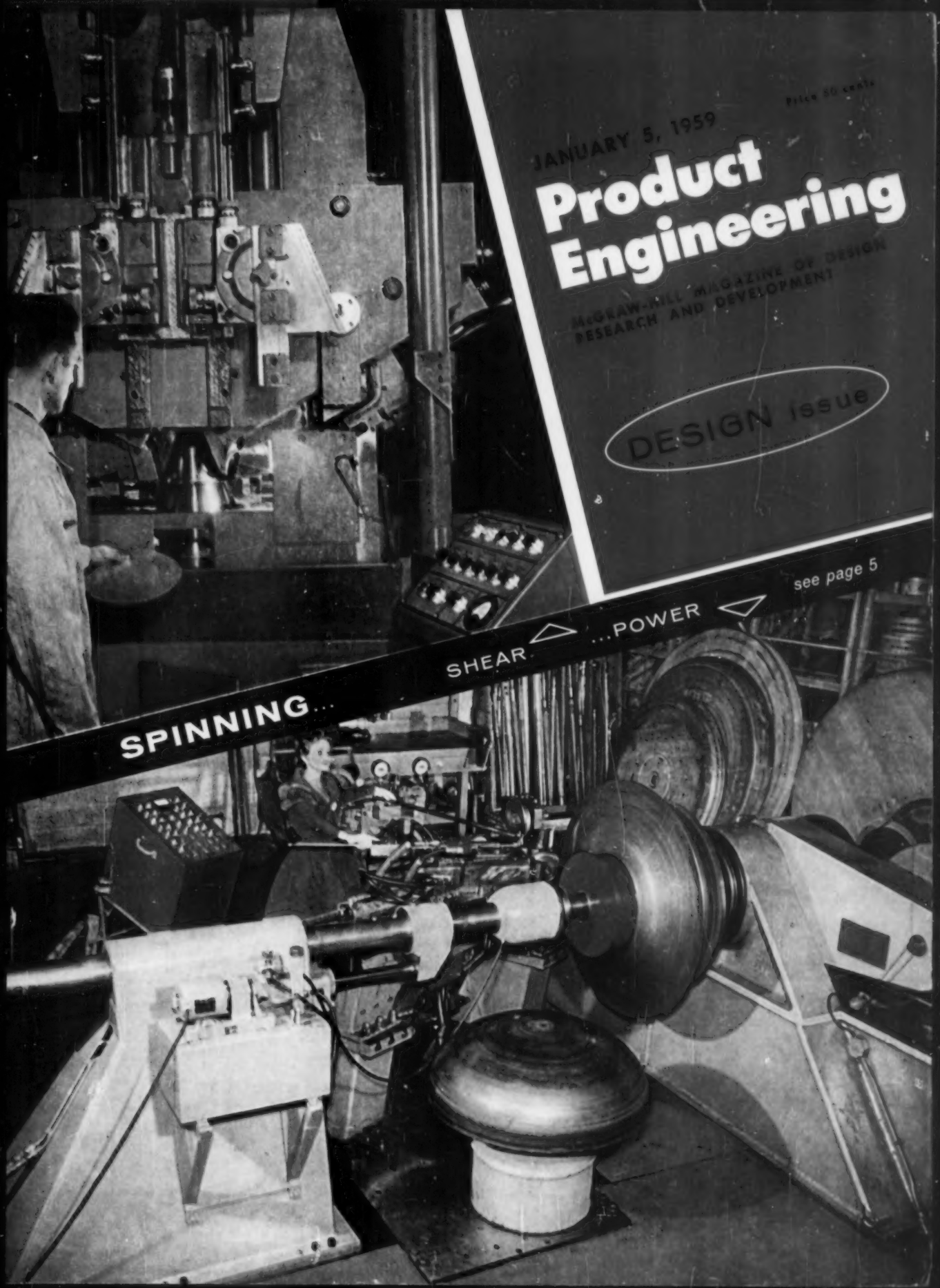
JANUARY 5, 1959
Price 50 cents
Product Engineering
McGRAW-HILL MAGAZINE OF DESIGN RESEARCH AND DEVELOPMENT
DESIGN issue
SPINNING... SHEAR ...POWER
see page 5

Now you can get standard sizes in C/R End Face Seals!

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

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Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

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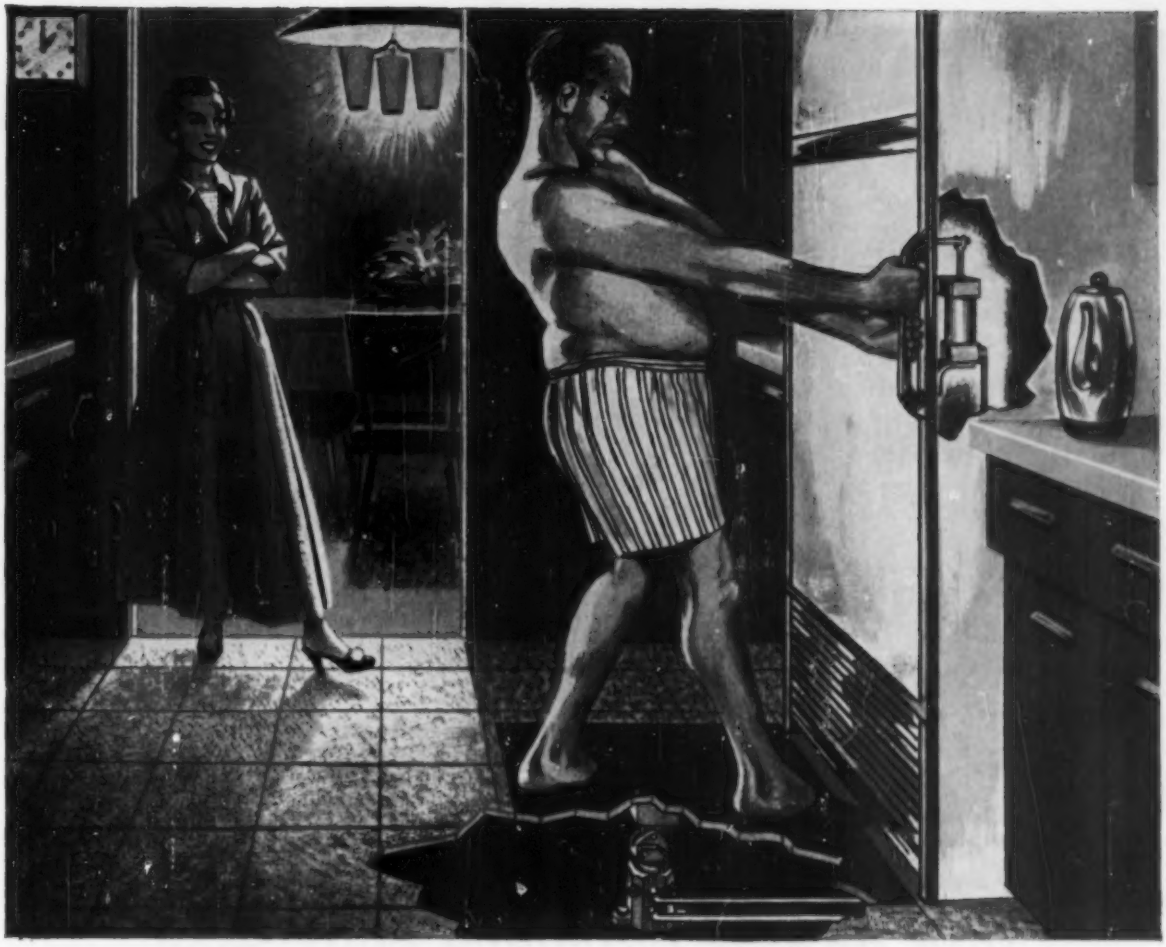
C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears



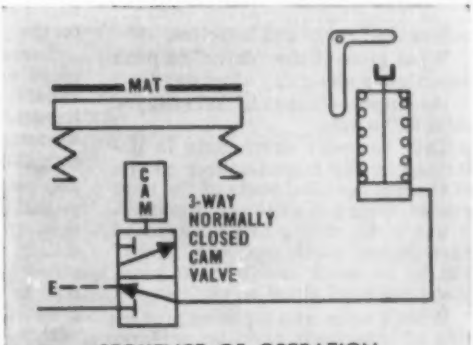
What? Air Won't Let Him Get Too Fat!

We admit we are not serious, but . . .

In a previous moment of strength he has set the controls—now, if he weighs over 200 pounds when he steps on the mat in front of the refrigerator, the door just won't open. But while he is under 200 pounds, no trouble. Now, it's highly unlikely that the refrigerator folks will be mobbed by eager buyers for such a diet-master model, but we have jumped on it as a good chance to show how a cam valve can say "yes" or "no."

Ross Cam Valves can "think" for your circuits, too

Cam valves are the key to air automation. They can act on almost any mechanical signal to set off . . . or restrict . . . another operation. Then still another cam valve can interlock that circuit with yet further operations and so on until any number of operations can be sequencing one another. Are you realizing the full possibilities from cam valves? The Ross line includes so many models, we invite you to call your Ross representative or write us.



SEQUENCE OF OPERATION

Sufficient weight on mat depresses cam, operating valve and moving cylinder to point where it restrains door handle from opening.

Ross OPERATING VALVE CO. E. Golden Gate Ave. • Detroit 3, Michigan

CUTS 'EM DOWN, right or left. This powerful motor grader, shown here doing "high bank-cutting," can work its big blade in many seemingly awkward positions. It depends on a drive axle of alloy steel containing Nickel to withstand rugged operating conditions. Photo courtesy of Le-Tourneau-Westinghouse Company, Peoria, Illinois.

How nickel-containing alloy steel keeps a workhorse shouldering its load

Step on this motor grader's accelerator . . . feel its 15 tons spring to life . . . as it rips out stumps and roots . . . scrapes out rocks and boulders.

What gives it the "drive" to push relentlessly along day after day?

Its super-strong nickel-alloyed steel drive axle.

This two-part drive axle is described by the manufacturer as one of the most critical parts of the road grader. Only 3½ inches in diameter, it has to be strong to push tons of hard-packed earth and rock. And it has to be shock resistant to withstand hours of abuse on the job.

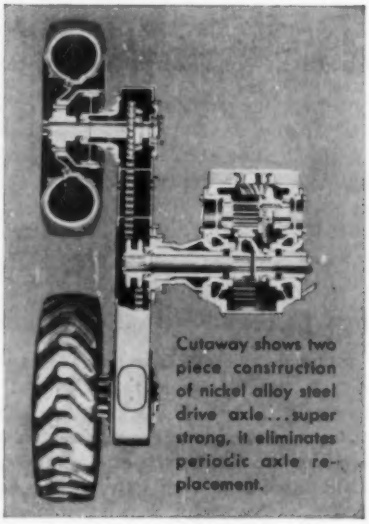
What's more, the superior properties of this shaft must be uniform from surface to center and from one end to the other.

Fortunately, Le-Tourneau-Westinghouse engineers had years of experience with shafts and axles on other similar equipment. They knew they could count on a nickel-containing alloy steel, AISI 4340 H, to take this punishment. Millions of hours on the job proved them correct.

Because 4340 steel is widely recognized as the general purpose alloy constructional steel for through hardening heat treatment, it is readily available from steel service centers throughout the country.

Are you looking for a metal with dependable strength . . . added toughness or corrosion resistance . . . excellent resistance to fatigue, shock, stress or wear? A nickel-alloyed steel may be just what's needed to help a product of yours "make the grade" with users. Talk it over with us. We can make available to you technical data based on years of specialized experience with alloys containing nickel.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.



Cutaway shows two piece construction of nickel alloy steel drive axle . . . super strong, it eliminates periodic axle replacement.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

JANUARY 5, 1959 Vol. 30, No. 1

5 Steps to Faster Reading 29... The Reading Laboratory Inc
Want to get more reading done? And get more out of what you read? Here's Lesson I in a series telling you how. Five other lessons are coming, one in each of the following issues.

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Powered—for Large Parts 42... Machine with built-in "feel" and hydraulic power produces heavy parts that can be shaped best by spinning.

Automatic—for Conical Shapes 46... "Shear-spinning" turns blanks into correctly shaped nose cones. In this method, rollers are under tracer control.

Static-pressure Transducers 48... H D Nunn, Daystrom Inc
Guide to transducers that have diaphragm, bellows or bourdon pressure cells. A future article will cover piezoelectric types for higher frequencies.

New Foamed Silicones 50... D E Weyer, Dow Corning Corp
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Design Features in New Products 52... Electromagnet holds mandrel to check bore as plastic tubing is extruded; with simple gearshift, locomotive pulls freight or speedy passenger train; lathe packaged for easy adjustment; swinging shear slices sheet squarely.

Mixed-flow Impellers 56... C A Hathaway, Torrington Mfg Co
They outperform older types where air pressure requirements are too high for axial and too low for centrifugal fans. Author supplies charts and equations for comparing performance.

Carpet Plotting for Hi-temp Data 60... Alexander Krivetsky, Bell Aircraft Corp
The old way needed two sets of curves to show interaction of stress, strain, temperature. Speedier, carpet method plots all such materials data on one sheet.

Design Review Catches Those Boners 64... D P Simonton, Radio Corp of America
Mistakes will be caught in time if capable colleagues look over the project occasionally to see how it is shaping up.

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Deflecting a Spring Sideways 71... W H Sparing, American Steel Foundries
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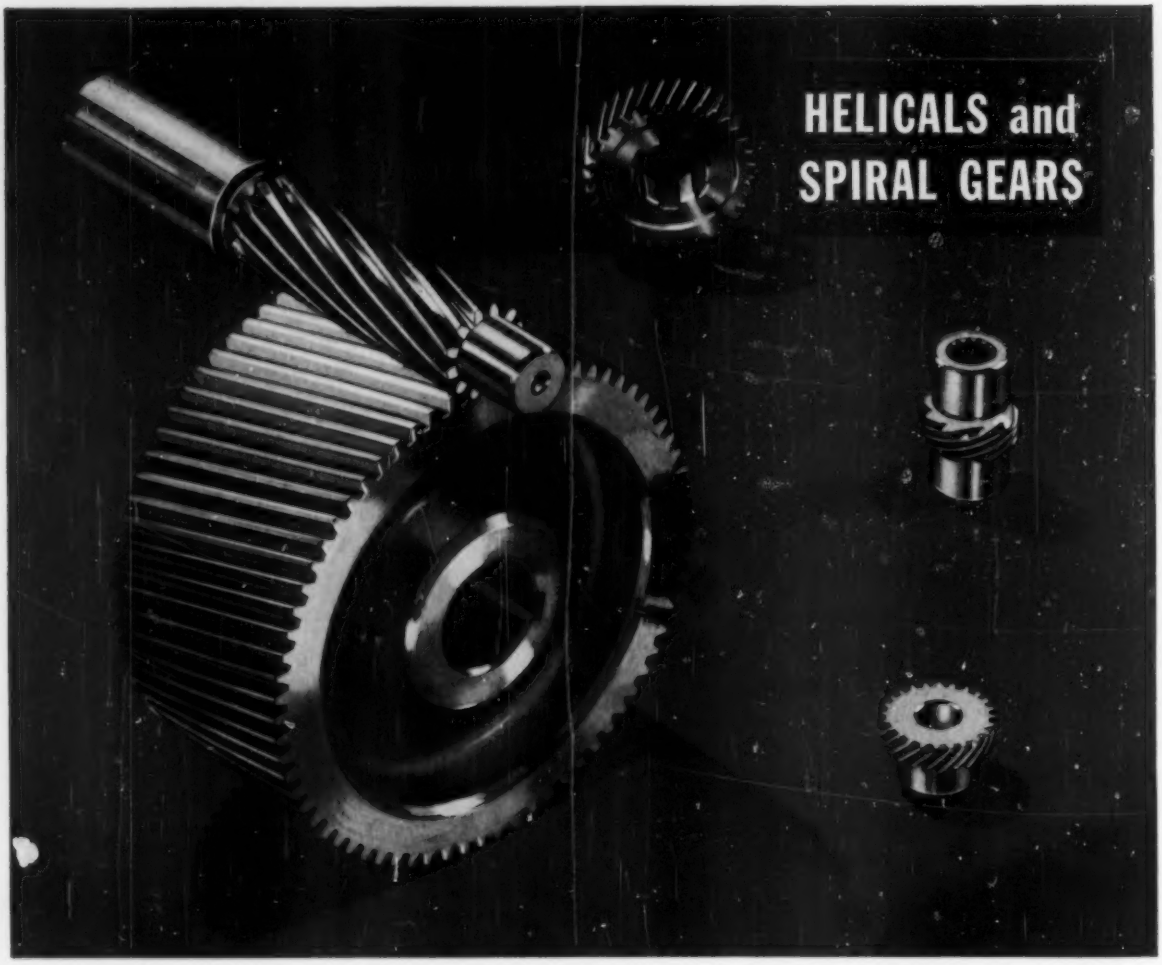

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Interesting to Note . . .

Spinning—an Ageless Art

The spinning that forms hollowware has no single origin. When man first saw need for a better way to transport liquid from a lake or stream to his living quarters, he devised a stone or clay container. With clay, he learned early that it could be worked by hand when wet and then hardened over heat. For symmetrically rounded shapes, easiest way was to place the plastic mass on a stove or wooden platform, then work it while it revolved. This was spinning and it goes back several thousand years before Christ. How technology does it today with ductile metals is shown on our cover and in the picture story on page 42. But even the old way was inspiration. Egyptians classified the potter's wheel among inventions of the Gods and believed that Num, the creator, fashioned man upon it. The Chinese added a cord to the wheel to mechanize it, and Europeans added a long axle with a large disk at the bottom. Then by kicking the disk the top wheel could be kept revolving.

Actually pottery was simply a step in the direction of containers. It, in turn, had replaced gourds, ostrich eggs and perhaps bamboo cups. According to Singer, *A History of Technology*, pottery has been found only in settled communities. Nomadic tribes could not transport fragile vessels, some as thin as 1/10 inch, so they used other containers—or animal skins.

Trains Could Be Worse—and Were

Since the end of World War II, railroad passenger service has been on a steady decline. The 1957 total revenue was 35.3% under the average for the '46-'50 period. In spite of this great slide, many new train improvements have crept onto the great iron road—aluminum cars, tubular-designed coaches, more powerful engines and the dual-purpose locomotive pictured on page 53—with a high-speed drive for passengers and, by shifting gears, a low-speed drive for freight. Although it's true that pigs can cross the country without changing trains while people can't, passenger service today is nothing like the ordeal our grandfathers endured.

Roadbeds in the last century were so bad that train sickness was to be expected on any lengthy trip. A derailed train was common—so common that passengers agreed when buying a ticket to help replace a derailed engine or coach should it become necessary. Tracks were laid so carelessly that more than one passenger

(Continued on page 7)

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ABP

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ABC

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FOR ORIGINAL EQUIPMENT MANUFACTURERS

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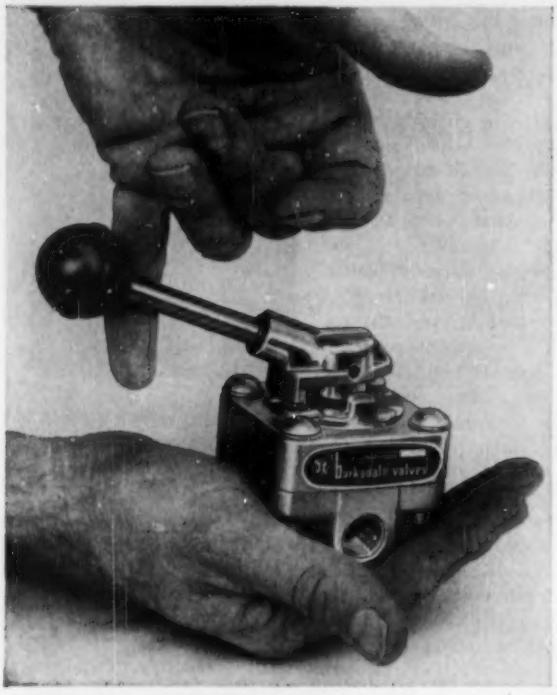
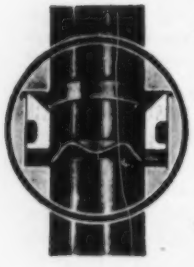


This is a re-design of our proven 250 P. S. I. air valve.

NEW FACE LIFT results in LOWER PRICE

None of the operating advantages of this rugged *'Shear-Seal'* valve has been reduced one iota!



. . . same non-corrosive construction throughout — eliminates failures due to rust.

. . . same long wearing leak-proof qualities — metal to metal *'Shear-Seal'* design is not sensitive to dirt, compensates for wear.

. . . same installation savings — because no oilers or filters are needed.

Only the exterior has been modified — tailored to the special preference of the Original Equipment Manufacturers — and, as a result, costs and prices have been substantially reduced.

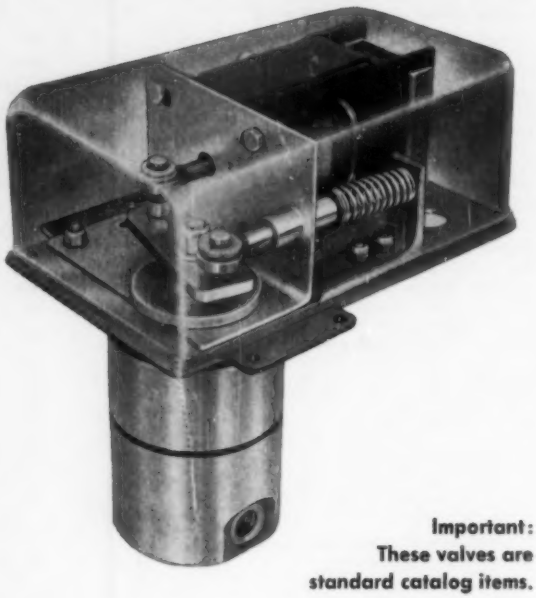
Write for bulletin 5000 which includes design specs.

CONTROL VALVE DIVISION

barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).

Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

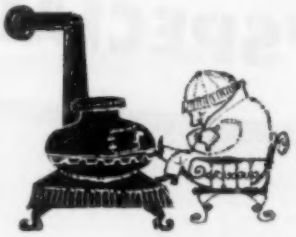
For complete data write for catalog S-10000.

CONTROL VALVE DIVISION

barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

became impaled on a rail when it broke and ripped through the flimsy wooden floorboards. Fire was always a hazard. Early engines were wood-burners that scattered sparks about the countryside; at night, a train looked like a Roman candle. In the winter, a pot stove in each coach kept passengers a few deegrees warmer than the outside temperature. And closed doors and windows shut in an air aroma of burning wood plus, rising through the floorboards, the stench of rancid animal fat used to lubricate the axles. Engine smoke would drift back through the cars, adding to the discomfort.



If there had been the choice of springs we have today (page 39) another major source of passenger gripes could have been avoided. For faulty roadbeds were not the only cause of train sickness. Seats were uncomfortable and the inelastic springs on the wooden coaches made the ride worse. In 1850, India rubber blocks were tried above the axles. It was found that they became rigid within a year and if frozen were completely valueless. Designers tried to ease passenger discomfort by spacing the wheels farther apart to lengthen the cars. While this curtailed the seesaw motion it led to serious wrecks when axles broke while negotiating sharp curves.

The poor, overpriced food served in dining cars today is at least available when the passenger wants to eat; not so aboard the early trains. To maintain train schedule, passengers often got only one meal a day at an eating house located beside the track. And because the train only stopped there for a short time, some places served food so hot a customer couldn't possibly eat it that fast. This allowed the food establishment to reheat and serve the same meal several times a day.

He Made Wampum Pay

Now that Congress is considering our largest peacetime budget (see p. 39) let's look back on the earliest mode of American barter—Indian wampum. Wampum making was a "mass production" industry in New Jersey at about the time of the Revolution and for at least two generations afterward. Sometime prior to 1775 there was a wampum factory at Pascack (now Park Ridge), NJ, about 25 miles from New York, which supplied the Indian money to fur traders over a wide area. The manufacturers were not counterfeiters, however, and there was nothing crooked about their business.

The business was established by a farmer of Scotch-Irish descent, John W. Campbell. This inventor of sorts made better money than the red men themselves could produce with their crude technique. Campbell even is credited with inventing a particular form of wampum, the "shell pipe." Though not actually currency, it was highly prized by Indians throughout the fur-trading area for decorative purposes, and it became an acceptable medium of exchange.

According to John C. Ewers, Smithsonian Institution ethnologist, the Indian who possessed many shell pipes was a rich man. Traders bought such pipes by the thousands. An especially good one, made for a few cents, was worth a beaver pelt to any Indian.

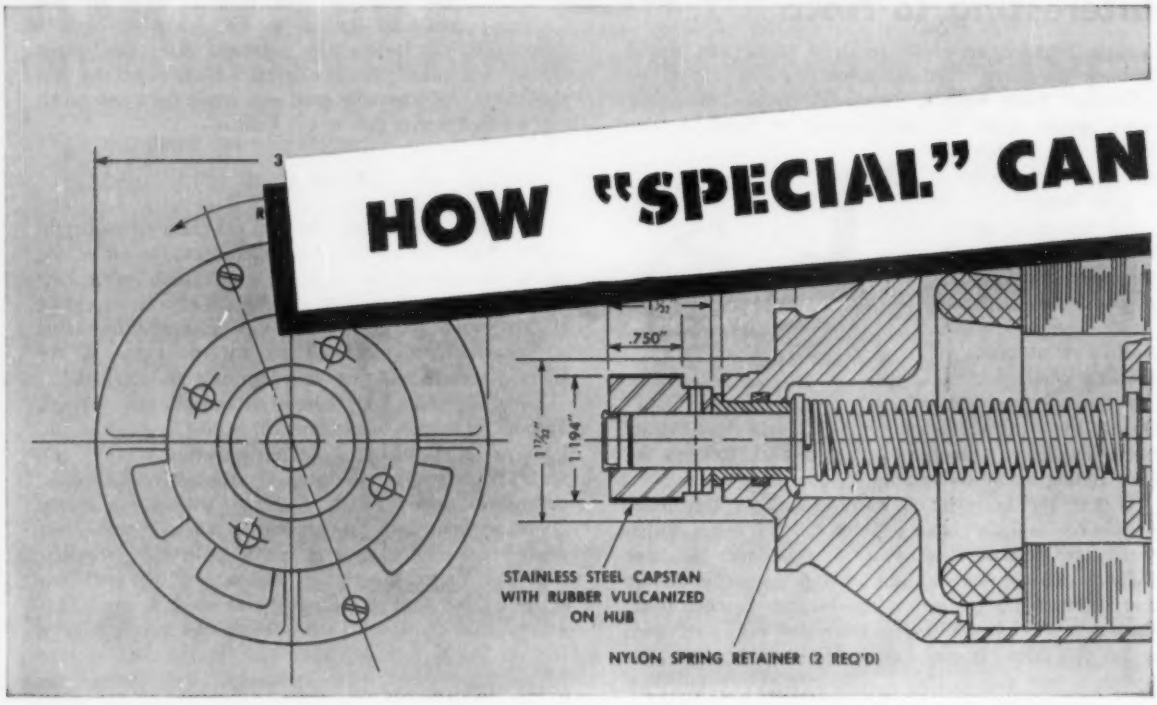
Keep Cool

Nowadays, the person who can get from an air-conditioned house to an air-conditioned store or office, via an air-conditioned car or train, can almost forget how miserable the summer heat can be. With the advent of air conditioning, even beer and soft drink advertisements no longer try to sell their products as a cure-all for summer's heat—now they tout lightness and dryness.

For quite some time before air conditioning arrived, millions of homes were content with the electric fan. Fans in the windows kept air circulating through the rooms while small units could be attached to bedsteads, dashboards or even book covers to maintain a steady breeze in your face. It all started when Nicola Tesla developed a small electric power unit. In 1889, together with the Westinghouse Co, he put on the market a small 1/6-hp ac motor driving a three-blade fan. This was the first commercial fan. Before this, people had to rely on mechanical devices similar to the 1850-vintage fan pictured here. (Two powerful clock springs are wound by handle to drive gears which turn the wooden propellers.) The big trouble with Tesla's early electric fan was lack of speed controls. Within two years, however, Westinghouse had an electric fan which could be regulated and looked much like the fans of today. But because home electric current was rare then, only the rich could afford the luxury of keeping cool. It's different now. Room air conditioners are almost as common as electric fans were only a few years ago. And a new mixed-flow impeller (page 56) just developed for air conditioners moves more air with less power and lower noise.

Credit: Electrical Merchandising

—Benedict A Leerburger Jr



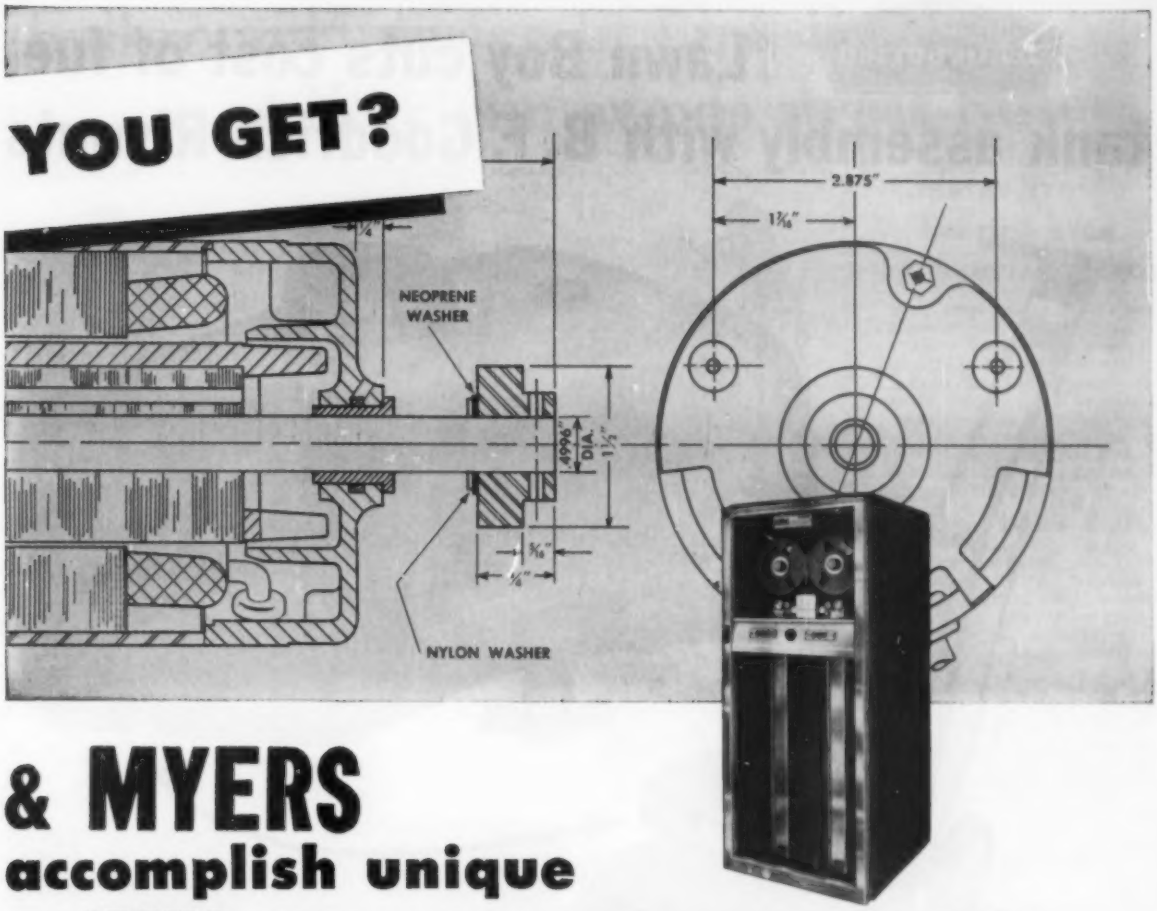
SPECIAL ROBBINS capstan motors function

SPECIFICATIONS

Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.

Robbins & Myers builds motors from 1/200 to 200 horsepower

YOU GET?



& MYERS
accomplish unique in IBM'S 727 magnetic tape unit!

SHAFT ROTATES AND MOVES AXIALLY

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units —driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

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Lawn Boy cuts cost of fuel tank assembly with B. F. Goodrich Rivnuts®

When Lawn Boy designed their current power mower models, they decided to *suspend* the fuel tank underneath the streamlined shroud. But in order to do this they needed specialized fasteners that would fit inside the tank and provide shock-proof, fuel-tight nutplates.

They found that B. F. Goodrich Rivnuts would do this job better and more economically than any other fastener. Here's how. After the tank is formed, two holes are punched in its top. One man takes only a few seconds to upset Rivnuts in these holes. Screws are then inserted through the shroud and into the Rivnuts, attaching the tank solidly.

B.F.Goodrich Rivnuts provide firm nutplates that won't vibrate loose during operation of the mower. In addition, the special closed ends and tight clinching action of Rivnuts form a 100% fuel-tight seal.

Rivnuts can be used hundreds of ways to simplify production—give your products more eye-appeal, more sales-appeal! If you haven't already investigated their potential in your own business, why not do it now?

Send today for free Rivnut Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. PE-19, Akron, Ohio.*

B.F.Goodrich *aviation products*

"Full-round" design of Link-Belt LXS chain avoids stress raisers

ROLLERS are accurately machined for correct operating clearances and free-rolling action.

SIDEBARS of selected steel have accurately machined "full-round" pitch holes, which maintain firm, tight press fit of pins and bushings.

FOR POWER TRANSMISSION, LXS chain is generally supplied with offset sidebars. Uniform stress distribution provides extra chain life and safe dependable operation.

FOR CONVEYING AND ELEVATING, LXS chain with straight sidebars and rollers to meet varied operating conditions. A wide variety of attachments is available.

"FULL-ROUND" PINS are made from a tough steel, specially treated for high strength in shear . . . sized for controlled press fit to prevent rotation in sidebars.

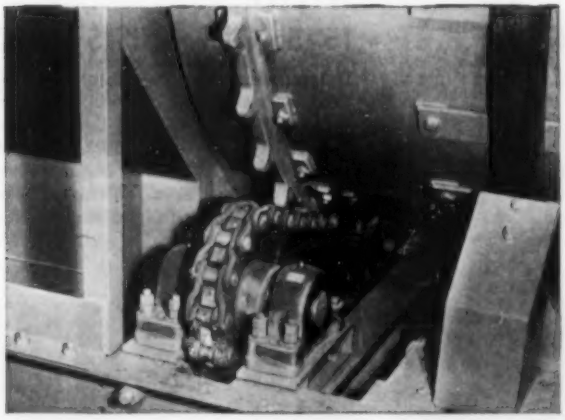
"FULL-ROUND" BUSHINGS are properly hardened to shrug off shock, resist wear . . . accurately sized for controlled press fit to prevent rotation in sidebars.

Greater live bearing area extends life

Stress concentration points are eliminated in Link-Belt LXS chain! "Full-round" design avoids sharp corners which may be the starting points of chain failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly . . . long chain life is assured under severe conditions.

Pins and bushings of LXS chain are accurately sized . . . assuring controlled press fits, preventing rotation in sidebars. Similar accuracy in machining of sidebars permits close control of pitch and proper chain length after assembly.

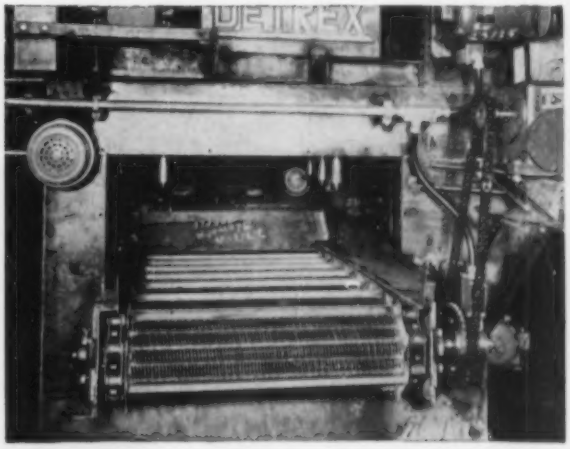
Other long-life features of Link-Belt LXS chain include use of selected steels and controlled hardening of all parts. Both contribute to greater endurance . . . greater uniformity.



LXS drives stand up to impact and abrasive service

Large, live bearing area makes LXS chain ideal for exposed drives and abrasive conditions such as found on this heavy rotating drum. Uniform distribution of load over ample bearing area reduces cutting action of abrasives . . . extends chain life.

LXS chain has stamina required for long, heavy-duty conveyors



With its exceptional strength and wear resistance, Link-Belt LXS chain can easily meet rugged conveying and elevating requirements. Due to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life necessary for the extra-long conveyors so important to today's highly mechanized industry.

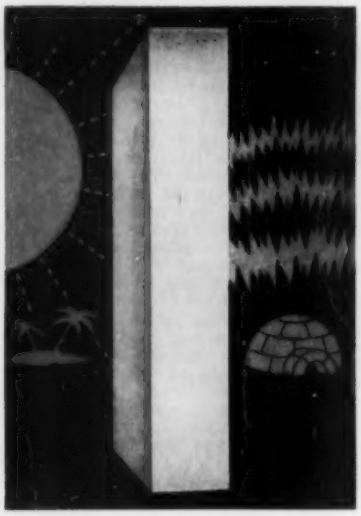
HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt office.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,741

FIVE REASONS WHY
IS THE BEST ANSWER



DYLITE IS AN INSULATOR

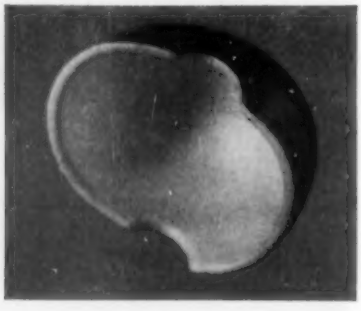
The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu. ft. density. DYLITE is highly resistant to the passage of heat and is unaffected by moisture condensate. DYLITE is easily molded to fit the contours of component parts of refrigerators, air conditioners and freezer cabinets.

DYLITE IS WATERPROOF

At 2 lb./cu. ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu. ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming waterlogged, and it is mildew-proof.

DYLITE IS SHOCK-RESISTANT

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu. in. at a density of 2 lb./cu. ft. For example, police safety helmets with shock-absorbent DYLITE liners are now used extensively—a result of performance tests in which DYLITE was proved superior to other materials for this job.



Typical Properties of DYLITE—Density 2 Lb./Cu. Ft.

- Compressive Strength—30 Psi
- Tensile Strength—55 Psi
- Water Vapor Transmission—1.18 Perms.
- Water Absorption—0.54 Lbs./Cu. Ft. After 48 Hrs. Immersion
- Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
- Energy Absorption (Maximum Load)—56.74 In. Lbs./Cu. In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLITE

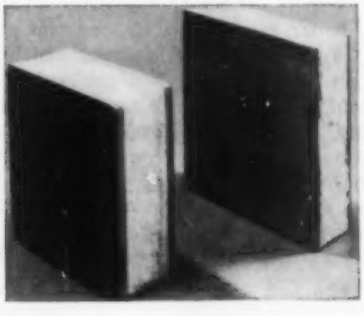
TO YOUR DESIGN PROBLEMS

DYLITE IS LIGHTWEIGHT

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu. ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

DYLITE IS STRONG

DYLITE has a Compressive Strengtn of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu. ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.



KOPPERS

Offices in Principal Cities: In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

KOPPERS PLASTICS

DYLITE

Koppers Company, Inc.
Plastics Division
Dept. PE-159
Pittsburgh 19, Pennsylvania

☐ Please send me more information on DYLITE expandable polystyrene.

☐ Please have Koppers representative call.

☐ I'd like more information on DYLITE concerning possible application in_____

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Announcing

—AN ENTIRELY NEW LINE OF V-BELT DRIVES

NEW HIGH CAPACITY!
NEW SMALL SIZE!
MANY NEW SAVINGS!

Dyna-V is entirely new. In every detail, Dyna-V has been engineered to take advantage of today's great improvements in belt materials and metal alloys—resulting in V-belt drives that are sensationally compact.

Dyna-V is capable of handling up to three times as much horsepower in a given space. Dyna-V opens vast new possibilities for better, more economical machine design. And, in most instances *Dyna-V costs less!*

An entirely new high in strength and horsepower capability is packed into Dyna-V Belts. Cross section dimensions are substantially reduced—top width is much narrower. Dyna-V Sheaves are designed for these belts. Narrower grooves reduce face width—and weight. Costs are lowered. Smaller diameter sheaves and shorter center distances multiply savings.

Increased sheave strength for increased capacity is obtained through changes in design that utilize the full benefit of modern improvements in alloy metals. Dodge is noted for the superiority of its semisteel castings, to which now have been added ductile iron castings produced with the most modern electric furnace facilities.

Dyna-V Sheaves are equipped with Taper-Lock Bushings. The superiority of this mounting, patented by Dodge, is widely recognized. Taper-Lock's holding power is terriffic, yet it is "easy on, easy off." And Taper-Lock Bushings provide the additional advantage of interchangeability.

The benefits of Dyna-V go beyond compactness and initial low cost. Smaller sheaves reduce shaft overhang—increase bearing life. The dimensional stability of Dyna-V Belts (which are heat resistant, oil resistant, static conducting) solves the problem of belt matching. Every belt carries its full share of the load. The crowned top of Dyna-V Belts is a new concept in belt design. Combined with proved concave sidewall construction, it insures perfectly even load distribution between belt and sheave.

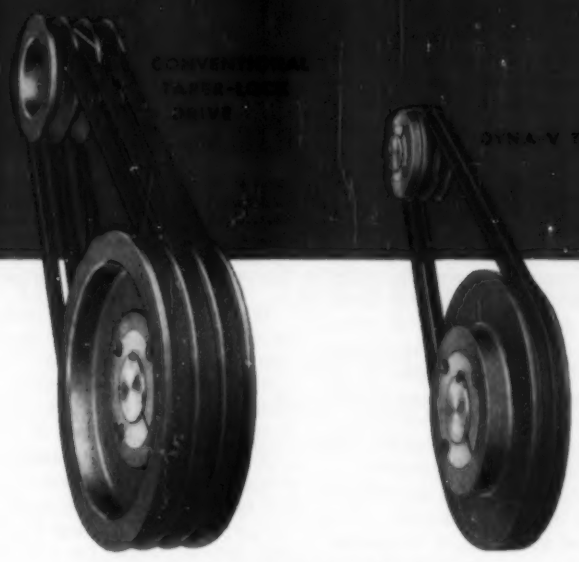
A complete bulletin on Dyna-V, including drive selection tables, will soon be ready. If you want one of the first copies, write us at once. Or see your local Dodge Distributor.

DODGE MANUFACTURING CORPORATION
1200 Union Street, Mishawaka, Indiana

DODGE

DODGE

Dyna V



Dyna-V Drives for capacities up to 50 horsepower are now available from stock, using the new belt cross section, "3V," and Dyna-V Taper-Lock Sheaves to match.

Dyna-V Drives for capacities up to 200 horsepower, using "5V" belts and sheaves will be available from stock in March. Larger sizes up to 1500 hp, with "8V" belts and sheaves, can be furnished on order.

COMPARISON, ILLUSTRATED ABOVE — 3 HP, 1750 RPM, 2.41 TO 1 RATIO

	BELTS		SHEAVES			CENTER DIS-TANCE	HP	WEIGHT (LBS.)	COST	
	Number	Size	O.D. Driver	O.D. Driven	Width				Per hp	Per Drive
CONVENTIONAL TAPER-LOCK DRIVE	3	A42S	4.15"	8.95"	2½"	12.3"	4.62	24.7	$5.91	$27.38
DYNA-V TAPER-LOCK DRIVE	2	3V400	3.35"	8.00"	1$\frac{3}{32}$"	10.8"	5.0	18.0	$4.50	$22.50
% SAVING *Savings vary with different sized drives*			19%	10%	56%	12%	+	27%	23.8%	17.8%

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

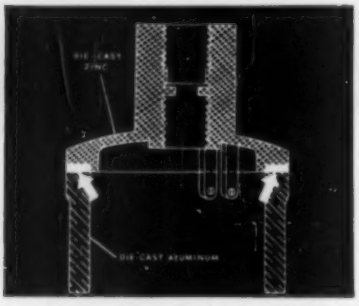
Technical data for gasket design and selection

NUMBER EIGHT

Avoiding electrolytic corrosion between flanges of dissimilar metals

When a joint is composed of dissimilar metals, the likelihood of electrolytic corrosion between flanges is greatly increased. In such cases, corrosion has been traced to plant fiber gaskets with glue-glycerine binders. Glue-glycerine binders are hygroscopic. The moisture accumulated in the gasket permits electrolytic action between dissimilar metals and results in corrosion.

A manufacturer of small gasoline engines was recently faced with this exact problem. Corrosion was attacking the aluminum float bowl and zinc float bowl cover, even on brand-new carburetors. Corrosion stopped when the gasket specification was changed to Armstrong CN-705 Accopac.



In this assembly, conventional plant fiber gasket permitted electrolytic corrosion between die-cast zinc and aluminum flanges. Switch to Accopac CN-705 eliminated this problem.

The non-hygroscopic binder in Accopac is synthetic latex. Since it does not attract moisture, corrosion cannot take place.

Accopac gasket materials are compressible, crush resistant, and will not shrink or dry out, even in alternately wet and dry applications. And because of their homogeneous nature, Accopac materials die-cut with sharp, clean edges.

Yet with all these advantages, Accopac costs less than materials of comparable quality. For more information about the advantages of Armstrong Accopac gasket materials, send for a copy of our bulletin IND-915.

Environmental factors in the selection of resilient gasket materials

In selecting a resilient gasket material, consideration should be given to certain conditions related to the internal and external environment of the gasket. These include such things as corrosion of flanges, the possibility of attack by fungus or ozone, and sticking of the gasket.

Flange corrosion. This can be caused by certain ingredients in the gasket, and it can also be the result of electrolysis between flanges of dissimilar metals. Both types of corrosion are usually associated with plant fiber gaskets that use glue-glycerine binders.

These corrosion problems can be avoided with Armstrong Accopac gaskets. Accopac materials have non-extractable synthetic latex binders which will not react corrosively with the contained fluid. These binders are also non-hygroscopic and will not encourage electrolytic action.

Gasket sticking. This is objectionable when a joint is subject to frequent opening and resealing and also where there is risk of damage to the flange when the gasket must be cut away.

Sticking is encountered most often where rubber-containing gaskets are used at ambient temperatures of 300° F. or above. It can be controlled or eliminated by coating the gasket with a release agent such as graphite.

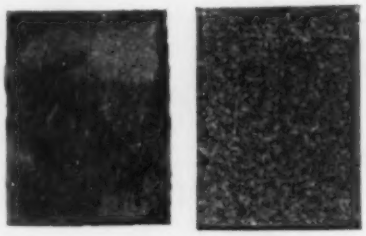
Sticking is not always an undesirable effect. In some cases, it acts to enhance the efficiency of the gasket.

Fungus attack. Certain atmospheric conditions favor the growth of mold and fungus, particularly on cork compositions and the more "corky" cork-and-rubber gaskets. This problem can usually be anticipated and can be prevented by the use of fungicides on the gasket.

A new Armstrong material—Uniphase Cork—is inherently fungus-resistant and can be used safely where fungus attack may occur.

Ozone attack. Ozone will attack and deteriorate some rubber and cork-and-rubber gasket materials. The extent of the damage is related to the concentration of the gas and the amount of stress on the gasket—with higher stress inducing more severe attack.

Among rubber and cork-and-rubber compositions, those using butyl as the base polymer offer the best resistance to ozone.



These samples of cork materials were inoculated with fungi in a standard test. Fungus attack on conventional cork composition is shown at left. Armstrong Uniphase Cork at right has special binder which makes Uniphase fungus resistant.

Where cork-and-rubber gaskets are attacked by ozone, it may be possible to substitute Armstrong Uniphase Cork. This material has many of the characteristics of cork-and-rubber, but it is completely resistant to ozone.

A more complete discussion of the environmental factors that affect gasket selection and performance is contained in the Armstrong Gasket Design Manual. Write for your copy to the address below.

For your copy of Gasket Materials catalog or new Gasket Design Manual, write to Armstrong Cork Company, Industrial Division, 7101 Irvin Street, Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

New motor development obsoletes today's application practices!

Only from Allis-Chalmers!

Super-Seal motors save up to 60%

Here's an amazing advance in motor technology! It's the *Super-Seal* motor line—an open motor design so completely unaffected by moisture, dust, dirt, oil, acids and alkalies that it can be used in many applications previously requiring more costly enclosed motors. *Savings range from 15 to 60%.*

Super-Seal motor superiority results from two distinct revolutionary insulating techniques. Available in any integral horsepower size, smaller *Super-Seal* motors incorporate a *Poxeal* stator. A durable epoxy resin encloses the stator, creating an electrical system impervious to outside elements.

In larger sizes, *Silco-Flex* insulation is used. In this system, silicone rubber is vulcanized into a homogeneous mass to form a flexible, moisture and heat resistant, void-free dielectric barrier around coils and leads.

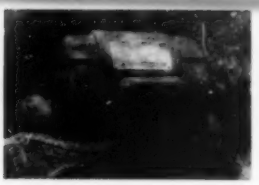
Both of these insulation systems are unsurpassed. Proof? An encapsulated motor ran for hundreds of hours at full load in a 4% brine solution.

Find out more by reading the next pages; then contact your A-C representative or distributor, or write Allis-Chalmers at address shown on back page.

A-C ALLIS-CHALMERS

51B 9100

Two revolutionary insulating techniques developed and pioneered by Allis-Chalmers mean savings of millions of dollars for motor users . . .



New open motors are unaffected by moisture and contaminants

Modern insulating materials and new methods of application, now available in *Super-Seal* open-type motors, are drastically changing motor application standards. These insulations are so completely impervious to moisture and contaminants that *Super-Seal* open motors can be used in most applications formerly requiring costly enclosed designs. Existing applications have resulted in savings as high as 60%.

Basic insulation systems

Larger *Super-Seal* motors with form-wound stator coils use the *Silco-Flex* insulation system. Heart of this system is a remarkable rubber-like silicone elastomer, applied in semi-cured state and vulcanized to form a void-free, impervious dielectric barrier. More than four years of development and field testing have proven the superior electrical and physical properties of *Silco-Flex* insulation systems.

Stator coils of smaller random-wound motors are protected by equally effective *Poxeal* insulation system. A tough, durable case of epoxy resin completely seals the winding end turns and slot portions. Bonded to the stator laminations, it forms a seal completely impervious to contaminants.

Moisture resistance

In addition to being void-free, the silicone elastomer used in *Silco-Flex* insulation is moisture repellent. Even in high humidity, moisture does not form a surface film of condensation. Coils with this protection can operate completely immersed in water. In fact, one of the recommended cleaning procedures is use of detergent and water.

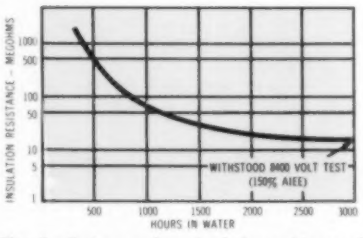


Fig. 1—Test curve shows insulation resistance of *Silco-Flex* insulation while immersed in water.

Moisture resistance of *Silco-Flex* coils is demonstrated in Fig. 1. After more than 3000 hours of total immersion with 2300 volts impressed on the coil, the test was terminated when it became apparent that little more drop could be expected in the coil's insulation resistance. At that point the coil still withstood a high potential test of 8400 volts without injury.

Encapsulated stator windings are equally well sealed. Motors with *Poxeal* insulation protection have been thoroughly tested under water while operating with full load and full voltage.

Resistance to contaminants

Silicone elastomers and epoxy resins are relatively inert to attack by practically all reactive agents. Further, the void-free construction of insulation systems used in *Super-Seal* motors prevents penetration of contaminants. As a result, *Super-Seal* motors are unaffected by oils, most acids, salt solutions, alkalies, and oils and are ideally suited for such applications.

Thermal stability

Temperature-wise, *Silco-Flex* insulation can easily withstand hot-spot temperatures of 200 C and more—

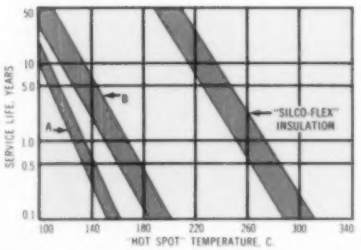


Fig. 2—Chart shows that *Silco-Flex* insulation more than meets Class H requirements.

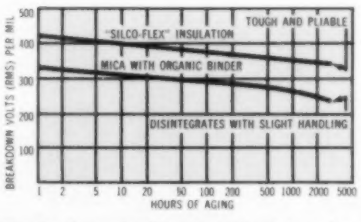
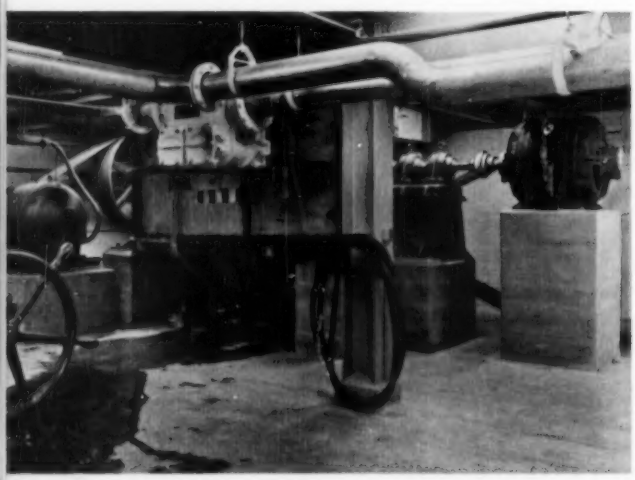


Fig. 3—Tests of 2300-volt insulated bars show thermal stability of *Silco-Flex* insulation.



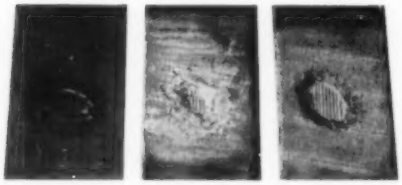
Paper mills have wide application for *Super-Seal* motors because of moist atmospheres.

easily meeting Class H temperature requirements (Fig. 2). At temperatures where the life of Class B coils would be measured in weeks, the life span of *Silco-Flex* coils is well beyond machine obsolescence.

Comparison with a mica-organic binder insulating system (Fig. 3) offers further proof of thermal stability. After 2000 hours of aging at 200 C with 8500 volts applied continuously, the *Silco-Flex* insulated coil was still tough, pliable, and completely serviceable. The mica-taped insulation had deteriorated to the point where it disintegrated readily and was completely useless.

An added advantage of *Silco-Flex* insulation is unusually high thermal conductivity — about twice that of conventional insulations. This means heat dissipates faster from its point of generation.

Poxeal insulation also demonstrates remarkably good thermal stability. Materials now in use are suitable for Class B temperatures, although actual classification of the insulation is determined by the basic material used.



Silco-Flex Insulation | Polyester Mica Tape | Asphaltum Mica Tape

Fig. 4—Samples of motor insulations after sandblasting give comparison of abrasion resistance.

Abrasion resistance

Resistance to abrasion is still another point of superiority in the insulation systems used for *Super-Seal* motors. Abrasion resistance of *Silco-Flex* insulation is compared to other types of insulation in Fig. 4. After one minute of sandblasting with 90-grit aluminum oxide and 100-psi air, only slight surface erosion appeared on the *Silco-Flex* sample. Other insulations were eroded to bare copper.

Application practices obsolete

The superior qualities of *Super-Seal* insulating systems, developed by Allis-Chalmers, make it necessary to reappraise present application practices. With virtually ageless insulation, *Super-Seal* motors assure more reliable service and require less upkeep than the best protected, conventionally insulated machines — and at considerably less cost.

Super-Seal, Poxeal, and Silco-Flex are Allis-Chalmers trademarks.

CHRYSLER · KIMBERLY-CLARK · GOODYEAR · SOUTHERN CEMENT · CONTINENTAL CAN · AMERICAN OIL · CELOTEX · SCOTT PAPER · HURON PORTLAND CEMENT · FORD · FIRESTONE · PACIFIC GAS & ELECTRIC · STANDARD OIL OF INDIANA · B. F. GOODRICH · DOW CHEMICAL · MARLEY · INGERSOLL-RAND · LINK-BELT

WIDE ACCEPTANCE
of Super-Seal motors proves their advantages

Cement, petroleum, chemical, steel, mining, paper, utilities, municipalities and general industry — outstanding corporations in every field are specifying *Super-Seal* motors wherever operating conditions are tough.

Cost and *superior insulation* aren't the only reasons. Users are getting MORE MOTOR, too. Here's why:

Standard totally-enclosed motors, 55° C rise, have a *service factor of 1.* In other words, "nameplate" horsepower is the maximum. A 40° C rise *Super-Seal* motor with *Poxeal* insulation, and a 60° C rise *Super-Seal* motor with *Silco-Flex* insulation have a *service factor of 1.15.* For comparisons on what this difference means in required motor sizes, see this chart:

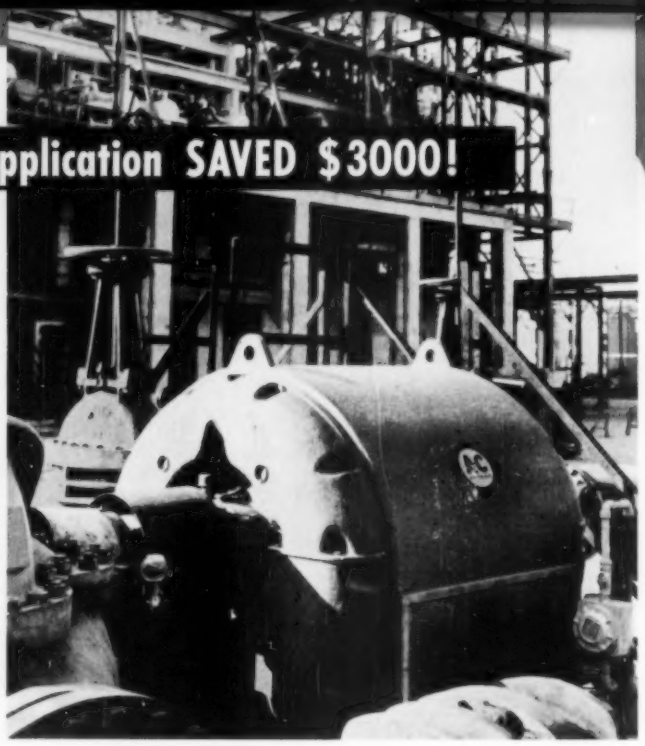
Rated Horsepower (Maximum Hp, TEFC)	Maximum Continuous Hp—Super-Seal Motor
15 hp	17.25 hp
25	28.75
40	46
75	86.25
125	143.75
200	230
350	402.5
500	575

Join the swing to *Super-Seal* motors. It will pay dividends fast. Contact your A-C representative or distributor, or write Allis-Chalmers at address shown on back page.

ALLIS-CHALMERS

SOUTHERN CALIFORNIA EDISON · LONG ISLAND LIGHTING · AVCO · UNION BAG · UNIVERSAL ATLAS · UNION CARBIDE · OHIO OIL · INTERNATIONAL PAPER · SOUTHERN PACIFIC PIPE LINE · ALCOA · ROHM & HAAS · ARMOUR · SHELL OIL · COMMONWEALTH EDISON · OWENS-ILLINOIS · WYANDOTTE CHEMICAL · BETHLEHEM STEEL · ALLEGHENY-LUDLUM · MEAD · DU PONT · DETROIT EDISON · ESSO · HERCULES POWDER · SINCLAIR PIPE LINE · GENERAL TIRE · MONSANTO

This *SUPER-SEAL* MOTOR application SAVED $3000!



Find out how much you can save

This application of a *Super-Seal* open-type motor — in place of a weather-protected design of the same rating — *saved the user $3000.00!*

You can achieve similar savings! Fill out the data sheet below and *find out for yourself how much you can save — on a "no-strings-attached" basis.*

Here's what to do: 1) Select an enclosed motor application in your operations (a new motor need or, for comparison, a motor just purchased); 2) fill out the data sheet; 3) mail to the address shown.

We'll give you a cost quotation on a *Super-Seal* open motor for that application.

Fill out this data sheet—

no strings attached—to find out how much you can save on a new motor or on an existing motor installation

To: **ALLIS-CHALMERS**
888 S. 70th St., Milwaukee 1, Wis.

Motor Data

1. Type (i.e., squirrel cage):

Horizontal ☐ Vertical ☐

Hp ..... Rpm .....

2. Phase ..... Frequency .....

Voltage .....

3. (For synchronous only)

Power factor .....

Starting torque .....

Pull-in torque .....

Pull-out torque .....

Application Data

4. Description of application:

5. Drive: Direct-connected ☐
V-Belt ☐ Other: .....

Starting load .....

Ambient temperature .....

6. Operating conditions: .....

Dirty ☐ Clean ☐ Wet ☐ Dry ☐

Other .....

Information on Existing Motors
(for comparison)

7. Type of insulation .....

Type of enclosure .....

Time rating .....

Temperature rise .....

Bearings:
Anti-friction ☐ Sleeve ☐

8. Special characteristics or construction: .....

NAME .....

TITLE .....

COMPANY .....

ADDRESS .....

A-5869

ALLIS-CHALMERS

DEVELOPMENTS TO WATCH...

Fuel cells come closer to commercial utilization . . .

. . . as more companies reveal results of research on these chemical-into-electrical energy-conversion devices *(PE—Nov 3, p 10, Feb 17, p 18)*. In most types now under development, hydrogen is fed into the cell at one side, oxygen at the other. In the resulting electrochemical reaction, an electrical current is created—often with remarkably high efficiency. Some cells now in operation achieve almost 100% fuel utilization.

Among the companies that have already announced results of their work in this field are Allis-Chalmers, National Carbon, and Patterson Moos Div of Universal Winding.

Now, Lockheed has thrown its hat in the ring with a fuel cell it claims has an energy conversion efficiency of 70%, and should be adaptable as a power source for industrial machinery as well as aircraft communications equipment. Within 5 years, Lockheed engineers believe, a fuel cell can be developed that would "yield sufficient energy for powering an auto or even a plane."

At the same time, Consolidation Coal engineers report work on high-temperature systems (930 to 1550 F), using a molten carbonate, and air and ordinary fuel gases, instead of high-purity hydrogen and oxygen.

All these cells are characterized by high output (Lockheed claims one that delivers 100 watt-hr/lb, as compared with about 10 for an auto battery).

The fuel cost of present-day cells is still high. However, as Everett Gorin and Howard Recht of Consolidation pointed out to the ASME, "It is clear that the fuel cell is an extremely promising method for generation of power, and there is every indication that a cell can be developed with sufficient stability and output for commercial use."

Magnetic inspection at 400 to 1000 parts an hour . . .

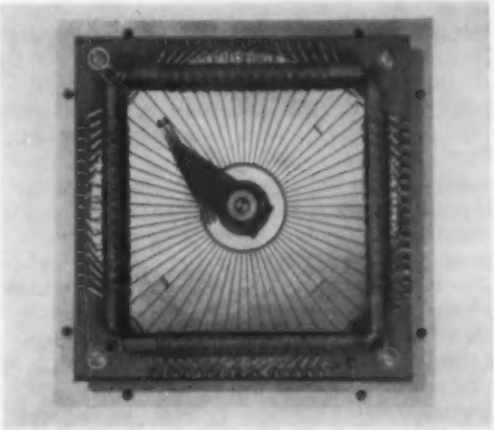
. . . is claimed by SREM of Pantin, France, for a small machine that "detects faults in fabrication or internal structure that are invisible to the naked eye —cracks, stresses, foreign material, and the like."

In operation, the parts (ranging up to about 6 in. long and 2 in. dia) pass between two electrodes maintained at high amperage but low voltage, and the unit is set to indicate any variation in the current flow. The fact that the voltage is very low makes the unit entirely safe, the French claim; they also say it's low in cost and has a number of built-in safeguards. Name of the unit: Contromag CV 600.

Variable delay lines . . .

. . . can be made more economically says Control Electronics Co, with a newly patented system that makes it possible to combine the switching and capacitor functions in a single printed segment.

CEC starts with a thin dielectric plate, coated with copper on both sides. The switch pattern is printed on one side, making the switch segments as large as possible. A solid ground pattern is printed on the other side. This, says CEC, permits the switch segments to do double duty as capacitors. The capacitance of each segment is, of course, dependent on the thickness of the material, which cannot always be controlled with the desired accuracy, as well as on the area of the segment. But CEC says it now has a simple, effective method, which constitutes a major portion of the invention, for "trimming" the segments with high accuracy.



To trim the cost of variable delay lines, CEC developed the design shown here. Unit formerly had 60 separate capacitors, requiring 60 drilled holes, 60 eyelets, and 120 soldered connections.

DEVELOPMENTS

TO WATCH...

Thermal insulating coatings for 3000 F and above . . .

. . . have been developed at Marquardt Aircraft; and, says Alan V. Levy, supervisor of the company's Materials and Process Section, they show good strength and ability to withstand severe vibration.

Two types of coatings have been made: flame-sprayed oxides and metal-reinforced ceramics.

Sprayed coatings (of ceria, chromia, and titania as well as such familiar materials as alumina and mullite) are considerably more flexible than solid bodies of the same type, owing to the porous, overlapping, scale-type structure produced by the flame-spraying process. It is therefore possible to apply coatings as thick as 0.080 in., and even higher in some cases. Coated components now under test include combustion chambers, turbine wheels, burner tubes, thermocouple tubes, and fuel injectors.

The reinforced coatings, says Levy, "are in the advanced stages of laboratory development at the present time." They're made by troweling a ramming mix onto a metal matrix attached to the base metal. Several types are under test: some have such reinforcements as stainless steel and molybdenum expanded metal, wire mesh, and metal strips brazed to the base metal; others incorporate ceramic fibers *(PE—July 7, p 70)* in the ramming mix. Ramming mixes are clay-type composites; phosphate-bonded alumina, zirconia, and chromia; and pure alumina and zirconia.

Such reinforced coatings have been found serviceable at temperatures to 4000 F. Tests indicate they can achieve a "marked reduction" in the operating temperature of the metal to which they are applied, and will withstand severe mechanical vibration, flexing, thermal shock, and recycling. They can be applied in thicknesses from 0.1 to 0.5 in. or more, and are surprisingly low in cost.

As to the future, Levy predicts that higher heating sources such as plasma jets *(PE—Dec 8, p 104)* will permit deposition of coatings serviceable to 600 F. Work is continuing with that goal in mind.

Note: A report on the first stage of this study (through June 1957) is available from Office of Technical Services, Dept of Commerce, Washington, D. C. It's PB 131752, 92 pp, $2.50.

A 20-fold increase in service life of synthetic fluids . . .

. . . can be achieved through use of new additives, Stanford Research Institute says. Tests now underway indicate that silicone oils which normally oxidize and gel in 10 hr or less at 518 F can stand as much as 200 hr of exposure when protected by the new antioxidants (SRI describes them as "condensed aromatic ring compounds"). Furthermore, SRI engineers claim, the new chemicals have no adverse effect on either the fluid or the metals with which it may come in contact.

Research on the compounds, and on the gelation mechanism is continuing.

Two new heavy-duty rotary switches are coming from England . . .

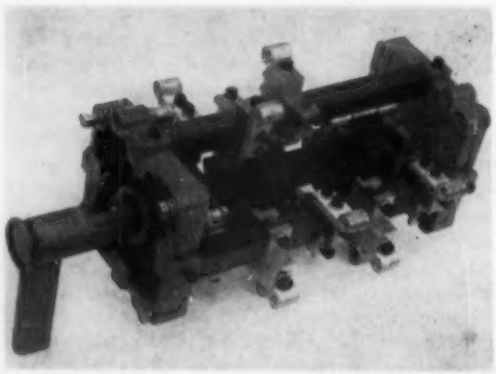
. . . One, for slow-break action, is now ready; the other for fast action, is undergoing operating tests.

The slow-break type, made in units up to 6 poles, will carry currents of 300 amp continuously per moving contact (500 amp with contacts in parallel) and will break 150 amp at 550 volts ac.

Tests of the quick make-and-break unit show it can break 150 amp at 250 volts dc.

Moving contacts are rotary with independent back-up springs. Handle mechanisms are available with 4 or 8 positions. Mountings at the rear provide for smaller switches to handle auxiliary circuits. Switches can be interlocked with Yale-type locks, figure locks, or smaller rotary switches—to interrupt the supply to a circuit-breaker holding coil, for instance.

Austinlite Ltd., Crawley, Sussex, is the switch manufacturer. —ARG



Rotary swiches for heavy duty applications have silver-plated copper contacts, with solid inserts at final position on fixed contacts.

Army Places Production Contract for First Long-range Guided Missile

DAYTON, OHIO, Jan 25, 1918—The world's first long-range guided missile will go into production here under a contract awarded Dayton Metal Products Inc by the US Army Signal Corps today. The design proposal presented by C. F. Kettering, director of the Dayton firm, outlines a low-cost, subsonic, air-breathing aircraft to be equipped with gyro guidance and barometric control, and covers the complete R & D program and tooling for quantity production.

The contract resulted from Kettering's work last year as a member of an advisory committee appointed to study the flying-torpedo design suggested to the Navy by Sperry. Although agreeing with the decision that the design presented was impractical, Kettering took strong exception to the committee's rejection of the principle and suggested a craft he calls the "Bug", to be powered by a 40-hp, 2-cycle, aircooled, opposed-cylinder motor, and incorporating gyro directional control and barometric altitude control. A knots-travelled counter cuts off the motor after a pre-set distance, causing the plane to dive into the target. Launching is from a prepared track system which incorporates a mechanism to abort the take-off if the "Bug" fails to develop sufficient lift to insure a successful flight.

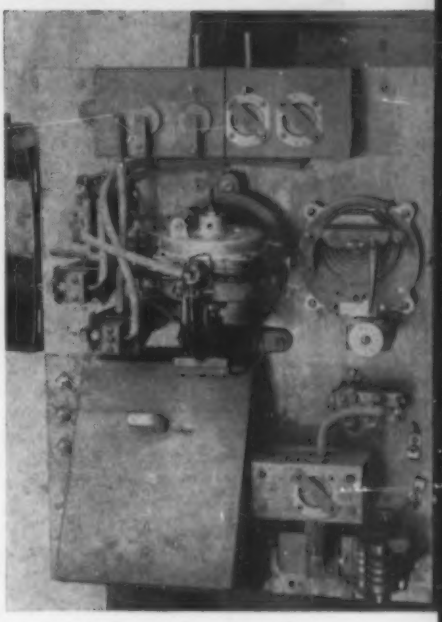
Intention of the program is to achieve a device that will outdistance a high-explosive shell, will be automatic, and will explode on landing, its parts acting like shrapnel. Meanwhile, it will not be armed until it has flown a sufficient distance to clear friendly territory. The "Bug", as Mr. Kettering has developed it, will cost $575 each in quantity; will weigh 320 lb complete, of which 200 lb is explosive and 30 lb is gasoline; will fly 50 miles with ½% error. It is to be assembled in 4 minutes in the field and can add 100 miles to flying radius by substituting 30 lb of fuel for that much explosive.

Initial production will be 25 units. Work has been divided into three portions: engine, controls, plane.

A 2-cycle engine is the choice because normal throttling difficulties are unimportant here, camshaft gears and valves are not required, and a crankcase check valve can provide pressure for the gas tank and air for the control. Initial experiments at DePalma Mfg Co, Detroit, resulted in dropping the original idea of two original motors and substituting a 4-cyl V-type engine with single-plane crankshaft, to cost $100 each in quantity. It has low vibration, weighs 120 lb, delivers 38 hp. Internal steel-plated aluminum cylinders, to reduce engine weight, were found not sufficiently durable, so were abandoned. Available carburetion systems were abandoned because they involved gravity flow, so the fuel tank would have to be above the wing. Air pressure through a check valve from the crankcase, plus a pressure-regulating valve to compensate for fuel use, solved the problem. Air at 150 F from one of the rear cylinders was used to heat low-gravity commercial gasoline in a heater, eliminating need for high- test gasoline, presently in limited supply.

Wings are modified from the DH-4 for a tractor-type biplane. Despite the suggestion of ailerons by both Orville Wright and Elmer Sperry, in each case pendulum controlled for automatic operation, Mr. Kettering substituted a 10° dihedral, thus avoiding many technicalities. It was at first intended to detach wings and set them afire over the target, so the fuselage would fall like a bomb while the wings became a floating incendiary. Difficulties with this device led to adoption of a simple ignition cutoff.

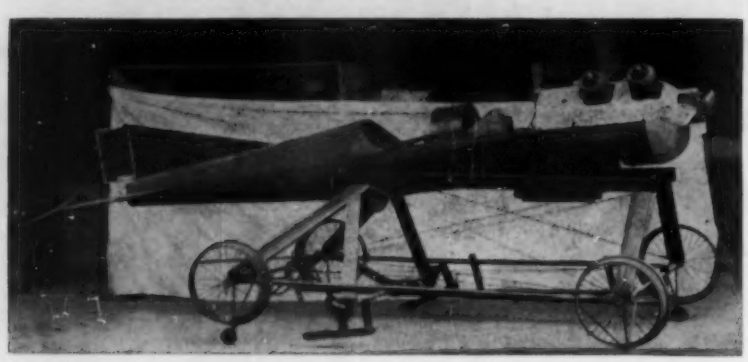
Editor's Note: This story was written from a report by one of the research engineers on the original project at the Dayton Metal Products Company. Hence the dateline—40 years ago, while we were in the first world war. This company, once owned by Charles F. Kettering, who died two months ago, has long since become a part of North American Aviation, Navan Div., from whose files the report and pictures were taken.



Control system breadboard . . . Includes air bellows at left top, gyro at center, barometer at lower right, relays at lower left. Electrical connections are by Fahnestock slips. Pneumatics introduced by Mr. Kettering resulted from his study of his Aeolian player piano. Wooden, steel, baby-buggy, rubber and finally coil springs were tested for holding the control panel vibration-free.

Wings are of cheap wood framing, covered with cloth, paper and cheap dope. Four struts connect the wings, which are rigidized by wire cross-bracing incorporating turnbuckles.

Controls are three in number: direction, altitude, distance. Directional control was to be by gyro, with electric clutches to operate a windlass carrying wires from control surfaces. But six precision ball bearings per gyro would limit "Bug" production to four per day, according to Mr. Sperry—only 24 bearings can be made in 24 hr. Experiments with compass control showed the plane would fly only in circles because of oscillation-period differences. (Mr. Sperry, incidentally, was enthusiastic about a compass-directed gyro, or gyro-damped com-



And here it is . . .
First ground-support missile is this "Bug", launched from a recoverable carriage on a track. Fuselage is cardboard built up on cheap wood framing, with a paper cone held on by wing nuts for a tail section. This saves scarce aircraft spruce and assumes the missile is not intended to be recovered. Control surfaces are flat plates of cardboard and paper for ease in manufacture and shipping, the vertical fin being offset ¾ in. to compensate for propellor torque. Brakes on carriage are tripped by a track dog to release it from the missile and avoid passing the track end, or can be tripped along the line by other dogs in case of malfunction.

pass, that was developed at one stage, but Admiral Smith was as violently opposed.) Hence directional-control experimentation was redirected to a gyro, but one using for vertical support the Westinghouse meter bearing —a single ball—below, and a simple loose sleeve above. Precision bearings were required to support the gyro case, but could be simple pivots, it was discovered, once steels and heat treatments gave 1½-hr life.

Similar reasoning resulted in substituting overloaded plain bearings, well oiled, for the rotor. Life was only 10 hr, but operaion was smoother, quieter, and required only 1 watt of power. Rotor and bearings were found to introduce error through wear of 0.00001 in. after a few minutes, however. Jewel, brass, bronze, nickel, nickel-steel, and other materials were all tested, but hard compressed fibre, treated with paraffin, was the only satisfactory one. With such bearings set loose, the rotor is brought up to speed, then the end bearings are tightened at speed.

Dc-driven gyros failed from brush and commutator wear, so ac was substituted. About 35% slip occurred at 11,000 to 13,000 rpm with such a drive. Power delivery is, however, difficult; this has been solved by grounding one wire, wrapping the other two once about the vertical axis, carrying it close to the precessional pivots and jumping across to the gyro case with bare No. 40 wire. Wires are clipped in small springs for ease of assembly. The ground could not be carried across the pivots, however, because of arcing and burning, so a spring-clipped #40 wire jumps from frame to casing.

The air-slot system, developed to "read" the compass (when the needle obstructs a slot), was adapted to the gyro to avoid precessional error from conventional reading. The unit is called a "balanced pneumatic" and comprises two small vacuum bellows working against each other. Relay valves like those in a player piano, were used to control the rudder. The hollow upper main shaft was also connected to a "balanced pneumatic," so if the "Bug" lowers or rises with respect to the gyro, shaft openings are restricted or opened, thus operating relay valves that control the elevator. The precessional effect of the gyro is utilized to make the ship climb initially, then the altitude control takes over, assisted by the gyro for leveling.

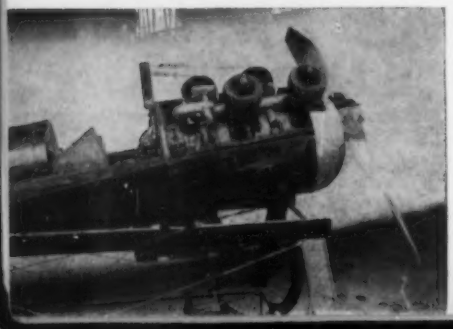
Altitude control was conceived by Mr. Kettering as an altimeter with direct-controlled valves. However, an aneroid barometer controlling valves directly was found to be better—at one time being sensitive to a 4-in. altitude change. But vibration and other problems required interposition of an electric relay with a damping device. This caused a make or break to take about ⅓ sec, so monetary vibration did not affect operation. Now accuracy is within 5 ft—good enough.

Mr. Kettering planned initially to control distance by counting revolutions of the propellor shaft, but Mr. Sperry and Mr. Wright insisted a separate propellor would be better. This is outside the slip stream, turns one revolution for each yard of plane travel (according to wind-tunnel tests), and is geared at 20:1 reduction to a make-and-break switch and relay operating an NCR customer counter which subtracts rather than adds. The counter is preset to the yardage desired before ignition cutoff, and simply shorts out ignition when all counter drums come back to zero and each releases a contact pawl.

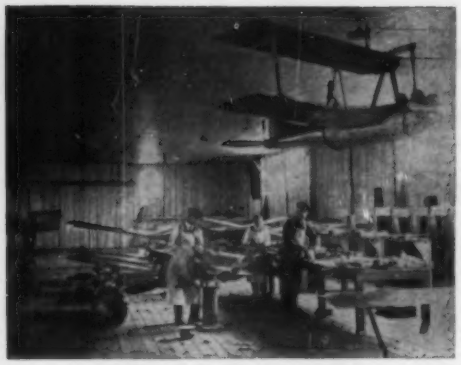
Ignition and relays are operated by 12-volt dc, and 3-phase 50-volt ac operates the gyro. Both are provided by an Alexanderson generator of the type used in wireless work. A standard Delco ignition system is used, except for the changes in the high-tension leads.

Launching is done from the 4-wheel device pictured. The "Bug" powers the launching gear, assisted by a slight downhill slope to the track. Brakes

Engine assembly mounted . . .
In plane before fuelage cover is in place Fuel tank is between engine and control bellows at left. High-tension leads go to a streamline support, then by bare wires incorporating a spring so they can simply be snapped over the plug end. Five other wires go back along the fuselage to the instrument board and a 5-point jack. This jack, powering the engine ignition, relays and gyro, disconnects after motor start so they won't short out the gyro.



The "Bug" . . .
America's first guided missile, set up for launching in Dayton, Ohio. A contract for 25 has been signed. Note auxiliary propeller on left wing to control distance.



First missile makers . . .

America's first missile production line is in Dayton. Photo shows propellors being carved from laminated wood by latest production methods.

built into the launching buggy are tripped at track end to prevent the "Bug" from carrying the carriage off the end of the track to a smashup. Levers along the track at 50-ft intervals can be set by cable to trip the brakes in the event of a bad launch, and will also cut out the ignition so the "Bug" will not pull the car to track end anyway. There is also a "fuse" wire which holds the "Bug" on the frame. This is a wire tested to 75-lb breaking strength, so the "Bug" must lift 75 lb over its own weight before it can fly free. This causes a "very pretty zoom which clears the car in very excellent fashion without a single mishap," according to engineers.

Articulated trolley buses . . .

designed by M.A.N. Maschinenfabrik Augsburg-Nurnberg AG Munich in West Germany (above) and another in the USSR are economical in operation and help to solve increasing traffic problems. Total length of the German train is 55 ft for a permissible load of 20 tons. Length of the attached carriage is 24 ft. It is steered from the pivot by a lever system. Radius of turn is 66 ft 8 in., and angle of lock is 50°. These accommodate up to 164 passengers, 47 sitting and 117 standing. The Russian version differs only in that its two articulated units are air conditioned and designed to accommodate about 200 passengers.

Name US Science Attaches to Six Countries

WASHINGTON—The State Dept has re-established its overseas science-officers program with the appointment of seven scientists to serve in the US embassies in London, Paris, Rome, Bonn, Stockholm and Tokyo.

Roster includes Dr. Thomas H. Osgood, Dean, School for Advanced Graduate Studies, Michigan State Univ, for London. Dr. Osgood is a physicist who has served for 10 years as editor of the *American Journal of Physics* and is chairman of the Publications Board of the American Institute of Physics.

Dr. Edward L. Piret, Professor of Chemical Engineering, University of Minnesota, for Paris. Recipient of a Fulbright research professorship, he taught at the Univ of Nancy and Univ of Paris. Recently he edited the American Institute of Chemical Engineering's fiftieth anniversary volume on "Chemical Engineering Around the World." Dr. Piret has taken an active lead in the International Relations Committee of the Engineers Joint Council.

Dr. Edward H. Cox, retired head of the Dept of Chemistry, Swarthmore College, as deputy science officer for Paris. An organic chemist, he is now in Thailand, advising the government there on educational policy in science. He has been a Fulbright research lecturer in France and an exchange professor at Heidelberg Univ.

Dr. Ludwig F. Audrieth, Professor of Chemistry, Univ of Illinois, for Bonn. This inorganic chemist has been on the Univ of Illinois faculty since 1928. An expert in nitrogen chemistry and codiscoverer of sucaryl sweetening agent, he is one of the originators of the chemical publication series on "Inorganic Syntheses."

Dr. Walter Ramberg, Chief, Mechanics Division, National Bureau of Standards, for Rome. An expert in theoretical and applied mechanics, Dr. Ramberg has held many offices in scientific societies.

Dr. Julius E. Mack, Professor of Zoology, Syracuse Univ, for Tokyo. He has lectured abroad and been in close contact with many foreign scientists, especially in Japan. In 1954, the AEC sent him to Japan (where he was Assistant Chief of the Biology Branch of the Division of Biology and Medicine) to study effects of fallout on the fishing industry.

Some of these scientists will start in January; others will leave for their foreign posts within a few months. London and Stockholm attaches will start a round of briefings this month in Washington, then be on the job overseas by late February.

Before end of this year, the government expects to fill similar posts in the USSR, India, and South America. Final diplomatic arrangements, however, still must be made before a science attache can be sent to Russia. Nor has the exact South American post been selected as yet—this attache will serve all of South America. Eventually the State Dept plans having both a science attache and a deputy at each post.

The program was first tried back in the period, 1951 to 1955, with attaches assigned to London, Paris, Bonn, Bern, and Tokyo. It was revived this year when Congress cracked hard at the lag in US programs for gathering technical information.

The State Dept says the science officer's primary role will be "to serve as an adviser to the Ambassador and his staff in the evaluation of the interaction of science with foreign policy, the assessment of current scientific progress abroad, and the enhancement of the liaison between US and foreign scientists and engineers."

Head of the program in the State Dept is Dr. Wallace R. Brode, science adviser to the Secretary of State.

First Science Academy for Arabs

CAIRO—The United Arab Republic is planning an academy of sciences, first scientific research center in the Arab world, and modeled after the Soviet Union's academy. The Soviets have promised to send a mission of R & D experts to help Egyptians set up the academy in Cairo.

Engineer Salaries Up 13% Since '56

NEW YORK—Over-all median of annual salaries for engineers in the US by mid-1958 was $8,750, up 13% from mid-1956. During this same period, the consumer price index rose only 1.5% while average gross weekly earnings for manufacturing industries climbed 10%.

These figures and more are contained in the third of a series of studies of engineering salaries conducted by Engineers Joint Council, scheduled for release by Jan 15. Survey covers salary status of 190,810 engineer graduates working in industry, government and education.

Subdividing engineers in industry, the survey showed the following median salary figures: for all engineers in aircraft manufacturing, $8900; design services, and construction, $8950; electrical and electronic, $8775; fabricating metals, $8450; primary metals, $8300; instruments, $8500; heavy machinery, $8325; R & D activities, $9575; transportation equipment, $8450; operating telecommunications, non-manufacture, $9350; and rubber, $8050.

Median salary for all engineers in industry was $8800, for engineers in federal, state and local governments, $8950—latter figure higher than industry because most government engineers have lengthy service, while most engineer graduates since WW II have joined industry.

Median salary for engineers with master's degree was $9825, while for Phd.s was $11,700. Average starting salary for all engineers was $5,850; for engineers in industry, $5,925; for engineers in government, $5,350; for engineers teaching, $5,600. Average starting salary for a Phd, $9,925. Of the 190,810 engineers queried, 3,313 were earning more than $20,000 a year, while 1,530 were earning less than $5,000.

1958 Median Earnings for Engineering Graduates by Year of Entry into Profession
(Baccalaureate Year)

Year	All Engineers Combined	Industry (155,124)	Government (30,028)	Engrg. College Teachers (5,139)
1958	$5,850	$5,925	$5,350	$5,600
1957	6,125	6,175	5,675	5,425
1956	6,475	6,525	6,075	5,700
1955	6,800	6,850	6,400	5,950
1954	7,000	7,050	6,700	6,225
1953	7,400	7,450	6,850	6,400
1952	7,700	7,725	7,078	7,100
1951	8,050	8,125	7,675	7,425
1950	8,350	8,450	7,775	7,500
1949	8,700	8,825	8,050	8,275
1947–48	9,200	9,325	8,325	8,625
1945–46	9,450	9,675	8,250	8,950
1940–44	10,250	10,450	9,050	9,875
1935–39	10,825	11,300	9,225	10,650
1930–34	10,675	11,350	9,325	10,850
1925–29	11,050	11,225	9,575	10,050
1920–24	11,200	11,850	9,425	10,650
1915–19	10,675	11,000	9,350	9,950
1914	9,500	11,000	9,225	9,175
Nos. Earning $20,000 and Over	3,313	3,125	10	161
Nos. Earning Less than $5,000	1,530	601	735	185

Comparison of Median Earnings, 1956-1958
(Approximate Increases for the Two-year Period)

Years from Degree	All Engineers Combined Dollars	% Increase since 1956	Industry Dollars	% Increase since 1956	% Increase since 1953	Government (all levels) Dollars	% Increase	College Teachers Total Income Dollars	% Increase
1	850	16	875	16	24	500	10	350	7
2	750	13	750	13	24	700	14	350	6
3	750	12	750	12	26	900	16	600	11
4	700	10	700	10	25	950	16	600	10
5	800	12	800	12	24	650	10	400	7
6	700	10	650	9	26	750	12	850	14
7	750	10	750	10	33	1,050	16	800	12
8	750	10	700	9	35	1,000	15	250	3
9	950	12	1,000	12	30	1,200	17	1,025	14
10	1,250	17	1,200	15	29	1,300	19	1,350	19
15	1,000	11	1,000	11	24	1,400	19	950	11
20	1,000	10	1,100	10	27	1,400	18	900	9
25	1,000	10	1,100	11	18	1,100	13	850	9
30	700	7	650	6	16	1,150	15	300	3
35	950	10	950	9	15	1,000	12	800	8
40	1,000	10	650	6	16	1,100	13	1,075	12

Industry increases closely parallel overall average increments. However, government increases for both absolute dollars and percentages, were above average. This reflects government success in raising general salary levels via flat increases granted during 1958 by Congress for engineers in government. Also, advances have been made by state and local agencies. However, government employment is still not competitive with industry. Earnings of engineers in government continue to lag most seriously behind industry at experience levels beyond 12 years—here 1958 government median line is far below 1956 industry median line.

Additional items of information that will not appear in Jan 15 report include: median age for all engineers in the US is 34-35, there are approximately 700,000 engineering degree-holders in US.

According to the council, results of the 1956 survey induced industry to part with information (or take the time and trouble to correlate it) that the council hitherto had difficulty obtaining.

GE Salaries Climb Since '52 but It's Mostly Keeping up with HCL

FORT WAYNE—Median annual salary increase for an engineer with General Electric Co since 1952 has been $590 according to figures compiled by the Statistics Committee of the GE Engineer Assoc. Results were tabulated from 7106 questionnaire returns, and classified according to employee age, level of performance (upper 10%, upper 25% and upper 50%) and covering the period Jan. '52 to Jan. '58.

First question: By what amount does the level of engineering pay rise each year because of inflation, higher starting salary, etc? GEEA Table I shows the average annual increase since '52; most of it resulted from inflation and there was only slight increase in market value of engineer. Amounts vary from $365 for a median (in the upper 50%) 25-year-old to $965 for a 40-year-old in the upper 10% performance level.

Second question: How much in

dollars annually is an additional year of experience worth to a GE engineer? Table II shows that for a median engineer, the value of a year's experience ranges from $350 for a 25-year-old to $160 for a 40-year-old. However, for engineers in the upper 10% performance level the year's experience was worth more—$450 for a 25-year-old and $400 for a 40-year-old. GEEA also learned that the value of one year's engineering experience is gradually decreasing, see Table III, in terms of per cent of total pay. Trend of decreasing salary increments as the engineer ages explains growing conviction by GE that there is insufficient salary potential in pure engineering work.

Final question: How much of an annual raise does an engineer require just to maintain his relative position in the salary structure? Combining Table I (increase due to inflation) and Table II (increase due to experience) provides figures in Table III. Any engineer who received an annual pay boost larger than that indicated for his particular level gained ground.

Table I—Average annual salary increase

Age	Salary Level, %	Average Salary 1952	Average Salary 1958	Increase per yr
25	50	$4,600	$6,800	$365
	25	4,900	7,400	415
	10	5,100	7,700	435
30	50	5,300	8,200	485
	25	5,800	9,100	550
	10	6,300	10,000	615
35	50	6,550	9,600	510
	25	7,500	11,200	615
	10	7,800	12,600	800
40	50	7,200	10,700	585
	25	8,400	13,100	785
	10	9,700	15,300	965

Table II—Value of experience per year

Age	Salary Level 50%	25%	10%
25	350	425	450
30	280	360	490
35	200	325	500
40	160	290	400

Table III—How annual increase due to experience decreases with age

Age	Salary level, %	1952 Increase	1952 %	1958 Increase	1958 %
30	50	$200	3.8	$280	3.4
	25	270	4.7	360	4.0
	10	360	4.7	490	4.9
30	50	170	2.4	160	1.5
	25	200	2.6	290	2.2

Table IV—Average annual increase combining inflation and experience

Age	Salary Level 50%	25%	10%
25	$715	$840	$885
30	765	910	1,105
35	710	940	1,300
40	745	1,075	1,365

Automatic welder . . . has boosted production of heater distribution chambers in GM's Adam Opel Works Russelsheim, Germany, by 600 units a shift, and has reduced assembly personnel from six to two. Designed by Voight and Haeffner, the heater-chamber assembly line includes four stations: At the first an operator locks subassemblies and single parts of the chamber body into a fixed position and between electrodes with levers. Locking engages the drive mechanism with transfer chain and moves the chamber to station 2 where the body is spot-welded at 20 points. At station 3, four holding studs are welded to underside of the chamber body. The welded assembly then travels a U-course along transfer chain to station 4 where the second human overseer has placed a threaded plate and drain-off pipe between electrodes. The chamber is locked into place here, and the electrodes advance to spotweld final parts to the chamber. Finished product then circles back to station 1. Time for round trip: 40 sec.

Electric Generators Heat Austrian Buildings

VIENNA—Hot air from electrical generators is being used as a source of central heat for buildings in a new system patented by the Austrian firm, Elin AG. The system is composed of a water heater, an air cooler and a control system to govern the two units. Air from the generator at about 130F is pushed through a water heater mounted on the generator stator, and the water then enters the heating system. Air leaves the heat exchanger at about 120F and then goes to a cooling unit where the temperature is further reduced to about 90F, and is then cycled back to the generator.

Liquid flow through the heat exchanger is determined by combination of need for room heat and electrical cooling. System is said to be capable of providing adequate heat for a building even when generators are idling.

COMING EVENTS

JANUARY

12-16 . . . . Society of Automotive Engineers, Annual Meeting and Engineering Display, The Sheraton-Cadillac and Hotel Statler, Detroit, Mich.

26-29 . . . . American Society of Heating & Air-Conditioning Engineers, 14th International Heating and Air Conditioning Exposition, Convention Hall, Philadelphia.

27-30 . . . . Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York.

28-29 . . . . Armour Research Foundation and American Welding Society, 5th Annual Midwest Welding Conference, Illinois Institute of Technology Campus, Chicago.

FEBRUARY

3-5 . . . . Society of the Plastics Industry, 14th Annual Technical and Management Conference, Edgewater Beach Hotel, Chicago.

6-7 . . . . University of California, 11th Annual Industrial Engineering Institute, Berkeley and Los Angeles campuses.

23-26 . . . American Society of Mechanical Engineers, Symposium on Thermophysical Properties, Purdue Univ., Lafayette, Ind.

25-26 . . . . US Atomic Energy Commissioner and Kansas State College, Midwest Industrial Radioisotopes Conference, Kansas State College, Manhattan, Kansas.

MARCH

3-5 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, Association for Computing Machinery, 1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco.

8-11 . . . . American Society of Mechanical Engineers, Gas Turbine Div., Engineering Conference and Exhibit, Netherlands-Hilton, Cincinnati, Ohio.

9-12 . . . . American Society of Mechanical Engineers, Aviation Conference, Statler-Hilton, Los Angeles.

16-18 . . . . Society of Automotive Engineers, National Passenger Car, Body and Materials Meeting, The Sheraton-Cadillac, Detroit, Mich.

READER TO EDITOR

Vacuum Comb for Barbers

To the Editor:

In reading the "Why Don't They Research and Develop" column (Nov 3, p 42) we noticed a suggestion for a vacuum cleaner comb for use by a barber. It has come to our attention that a similar device is now in use at the Wrigley Building Barber Shop in Chicago and that the patent application has been filed by the inventors, Messrs. Bernard Passmore and George Janice.

We also note a comment regarding the shortcomings of India ink. The problem of an ink which will dry rapidly on the paper but at the same time will not clog pens has plagued draftsmen for a long time. Any draftsman who has worked on a "light box" has observed that the heat from the lights dries the ink very rapidly and so perhaps a heated drawing board could be developed to accomplish that purpose. We have also experimented with mixing Parker 51 jet black ink with ordinary India ink and a certain amount of improvement in drying time can be obtained at the expense of more difficulty in erasing.

—W H Sparing
American Steel Foundries

Would Holes Help?

To the Editor:

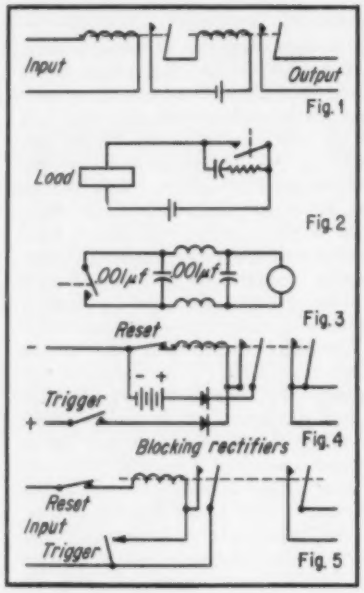
Volumes could be written around your editorial ("Design Apologies," Sep 15, p 73) but to me, it would boil down to this:

1. All our advances has come from very few "free" or "new" thinkers.
2. Since the rest of us didn't think of it first, we consequently refuse to accept, or try the innovation.
3. Our tremendous technological and scientific advances over the past few years reflect the philosophy of starting from the basics and working up.

You have a perfect example to illustrate your editorial. In the same issue is "Navy Develops Propeller for Super Speed Craft" (p. 41). It seems to me that some holes drilled through the propeller blades at the right places would tend to break up the cavitation or vacuum. But wouldn't an airfoil type prop have the old screw beat all hollow?

—A J Phillips
Portland, Ore

• We are reminded of the story of the prototype airplane which lost its wings at the roots every time they attempted to fly it. Finally the plant's general manager offered to accept anyone's idea, no matter how crazy, for stopping wing root breakage. The janitor suggested that a row of small holes be drilled along the root. This seemed obviously to weaken the wing root still more, but the general manager had agreed to try anything so he had the holes drilled. To everyone's surprise the plane flew with no trouble. As a result the janitor was promoted to engineer. The general manager asked the janitor how he had arrived at such a radical solution. Explained the janitor, "I never had an engineering education, nor much education at all, but I noticed that you have rows of little holes across toilet paper and it never tears at the holes."—EJT



Digest Correction

To the Editor:

While reading the article, "Sensitive Dc Relays" (Design Digest Issue of Mil-Sep '58, p 18) I came across several errors in the figures as printed. Attached are my versions of what was probably intended. As you can see in Fig. 1, part of the relay contacts are missing. In Figs. 2 and 3, I have used more modern symbols. As indicated in the text concerning Fig. 4, buzzer action can result with the contacts as shown. A make-before-break contact is more satisfactory. In addition, it should be mentioned that the polarity of the input should agree with that of the local battery. Fig. 5 as shown would not operate in the manner described. Although the reset button as redrawn is on the opposite side of the relay coil from the trigger, it need not be, and therefore the relay may be connected directly to ground.

—E U Thomas
Specialties Inc
Syosset, NY

R & D at Renault

To the Editor:

In your article, "Foreign Countries Move Slowly Toward More R & D Spending," (Aug 18, p 29) you mention that the major part of Renault's 1000 research engineers and technicians work toward cost reduction of existing models. We would like to comment on this information which is incorrect.

As of the end of 1958, the number of persons employed by us in research and development will reach 1050 persons, representing 1.7% of the total personnel of the company. Scientific research on materials and their utilization techniques employ 162 persons, while research on automobile technique occupies 110 persons, so that a total of nearly 30% of the said personnel is employed in research proper, without any direct connection with the study (i.e. the design) of prototypes whose manufacture is planned at a longer or shorter term.

From 1954 to 1960, we have invested nearly 2.5 billion francs ($6 million) in the following research and development facilities: one technical center, one test ground with a total area of 135 hectares (334 acres), and one tropical test center in Africa. The following figures give an idea of the general results which this effort has enabled us to achieve: Number of patents filed since 1949—in France, 141; in Germany, 10; in the USA, 15; in Great Britain, 33. Number of kilometers covered on test tracks in 1957 was 3.5 millions. Total output of the company—in 1950, 142,000 vehicles; in 1957, 336,000 vehicles. Since 1949, 13 papers were submitted to the Academy of Sciences; in 1952, the first locomotive using a free-piston generator was placed in operation on a trial basis at the French National Railways Co, where it has given dependable service since then, thus demonstrating the value of this new technique for the future. Finally, in 1956, the *Etoile Filante* ("Shooting Star") experimental turbine-type car beat the record of 300 km/hour in the United States near great Salt Lake.

In conclusion, we would like to confirm the remark made by a French industrialist whom you quoted in your article, to the effect that European industry does not make any propaganda about its research work. An outside observer may too often be inclined to compare on the same footing the very fragmentary information published in the European press with the abundant information so generously spread by the US companies. Nevertheless, we do believe that the exchange of information among technicians promotes progress and is, in the last analysis, beneficial to society as a whole. Therefore, in an effort to avoid both old-fashioned secrecy and excessive propaganda, we practice such exchange of information away from public notice, and you may find echoes of such exchange in many of our technical and nontechnical magazines.

J Grospiron
Head of Information Services
Renault, Seine, France

LESSON 1 . . .

FIVE STEPS TO FASTER READING

By THE READING LABORATORY INC

Too many things compete for the engineer's time and attention. You have to get your day's work done. You must read to keep abreast of new data, new ideas, and new developments in engineering. You must, in whatever leisure time remains, keep up with world affairs and keep yourself, as a human being, from going stale. How are you going to accomplish all of this–and do it well? You can't add more hours to the day; probably you can't cut down work hours. But in one area you can reduce time spent, and work more efficiently. That area is reading.

Everyone can learn to read faster and more efficiently. This article and the five articles that follow will introduce you to techniques which can help you to double or even triple your reading speed–while you're learning more from what you read.

The basis of better reading is phrase reading: reading meaningful thought units rather than isolated words. If you are a slow reader, as many people are, you are probably reading by the same method you used when you were very young–by seeing, saying, and hearing each word, one after the other. Then your reading training was dropped. In the next article we will pick up your reading training again and show you how to read by seeing only. In this way you can learn to see and absorb an entire meaningful phrase at once, in the time it used to take you to see and absorb each word. Your reading rate and comprehension will improve together.

Efficient reading techniques are just as important as increased rate and comprehension. You will learn from the third article in this series how to read more efficiently by getting a preview of what you read. Pre-reading tells you whether to skip, skim, or read thoroughly. The fourth article will present methods for improving your concentration. The last two articles show you how to get more from what you read by reading with a purpose and varying your approach.

How fast do you read now? How good is your comprehension? Find out by turning to the article "Mixed-flow Impellers" on page 56, which contains 1850 words. Use a clock or a watch with a sweep second hand and note the total number of seconds it takes you to complete the article. Convert this to words per minute. Now answer these five comprehension questions, selecting the correct answer for each.

1. The new fan has higher efficiency but noise is **higher, the same, lower.**
2. Its discharge is **axial, conical, radial.**
3. In the fan-performance curve, air flow is tied in with **speed, diameter, static pressure.**
4. Effect of housing is **small, none, large.**
5. For high flow rate and low pressure the best type is **radial, axial, mixed flow.**

What do your scores mean? Naturally, all material should not be read at the same speed. Highly factual and detailed articles–most of your scientific reading matter–should be read at a slower rate than nontechnical material with which you are reasonably familiar. The untrained reader reaches an average rate of 250 to 300 words per minute on nontechnical material. Do not be surprised if your reading rate is lower than this; the person accustomed to reading a great deal of technical and scientific literature often reads all material at a very slow pace.

Each comprehension question you answer correctly is worth 20 points. (You will find the answers on page 59.) If you scored below 60 points, you are not getting enough out of your reading.

In the sixth article of this series, when you have learned to apply the techniques of skillful reading, you will be asked to read another article on the same level of difficulty. Then you will be able to see for yourself just how much your reading speed and comprehension have improved.

Next week's lesson will tell you more about phrase reading–the key to faster reading speed with improved comprehension.

A more complete discussion of all aspects of reading improvement, plus practice exercises, is available in the book *Cut Your Reading Time in Half*, written by The Reading Laboratory and available for $1.25 from its publisher, Developmental Research Institute Inc, 500 Fifth Ave, New York 36.

creative designing calls for an open mind

Leonardo Da Vinci's design for a pump using the Archimedian screw principle

Model courtesy of IBM

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Uniform Class 3A Threads

Allenpoints' smooth, uniform threads prevent off-lead conditions like Fig. 1. With Allenpoints, you have full, even contact between the engaging flanks of the threaded members (Fig. 2) —and a tight friction lock over the entire length of the Allenpoint Set Screw.

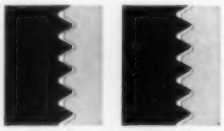


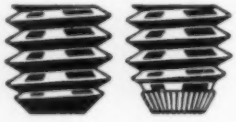
Fig. 1 Fig. 2

Strong, clean, deep sockets allow full wrenching leverage

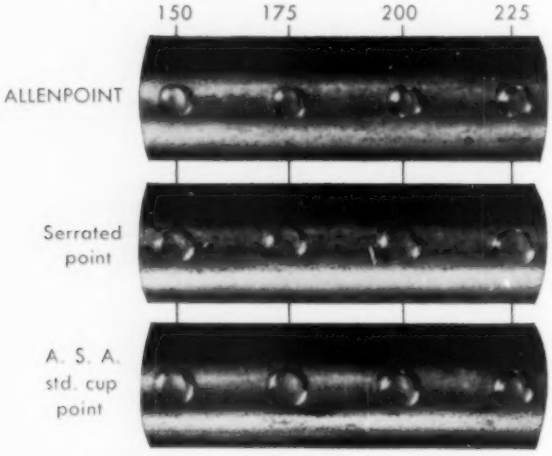
Sockets of Allenpoint Set Screws are cold forged to produce a deeper, smoother socket. No broach chips to interfere with proper seating of the key. This "pressur-forming" preserves the long steel fibers throughout the length of the screw—stronger walls allow maximum tightening torque.

One more full thread on ALLENPOINTS!

Allenpoint Set Screws have one more full thread than serrated point set screws. That means more holding power—especially important when you're using short lengths.



ALLENPOINT's performance compared for you



These actual-size, unretouched photographs show the cup pattern made by Allenpoints, serrated points, and A.S.A. standard cup point set screws in a 3/4" steel shaft. At each degree of tightening force, Allenpoints make a full circle pattern, penetrating deeper for greater holding power.

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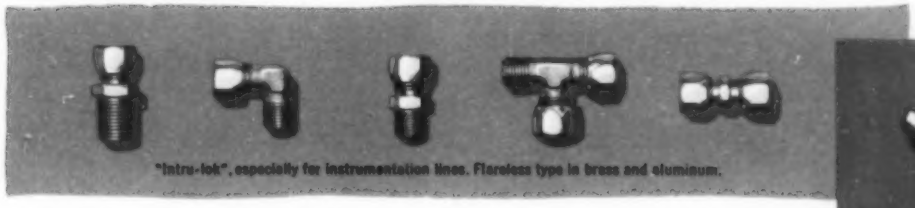
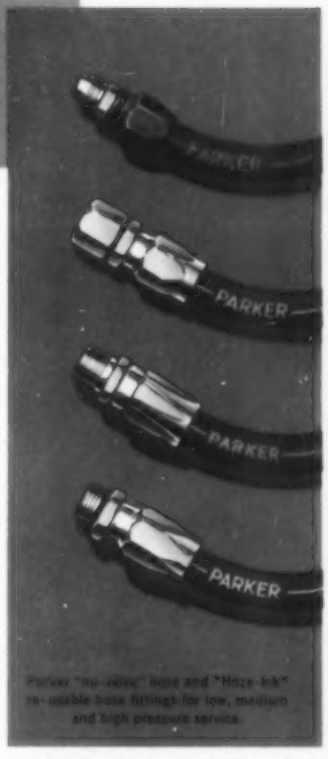


"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



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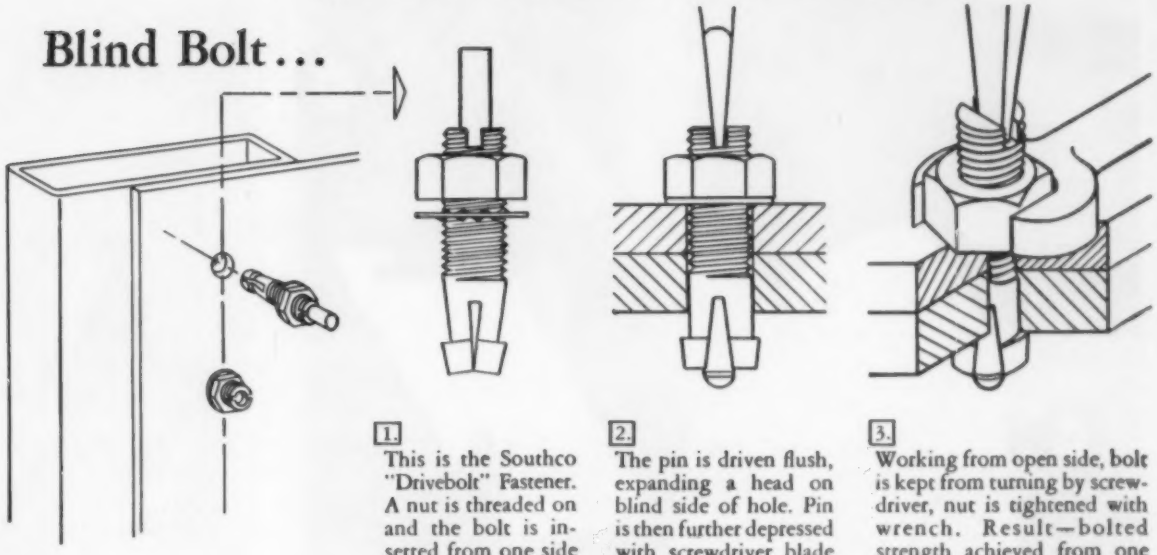
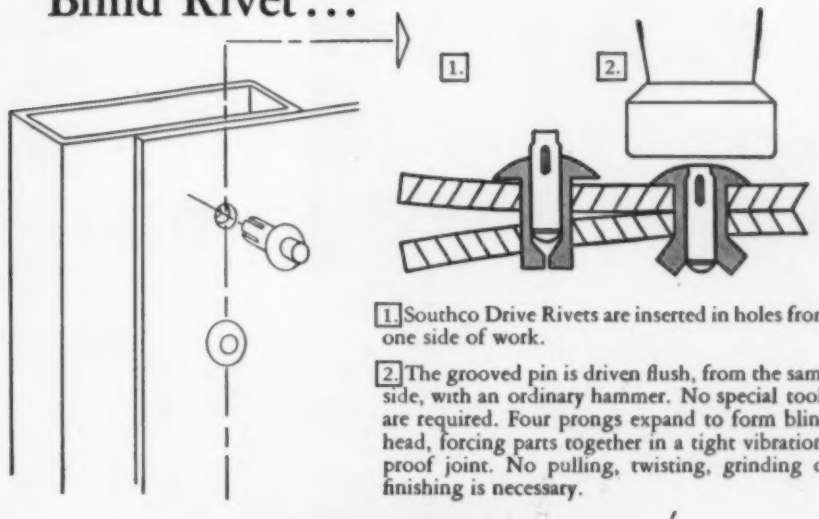


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

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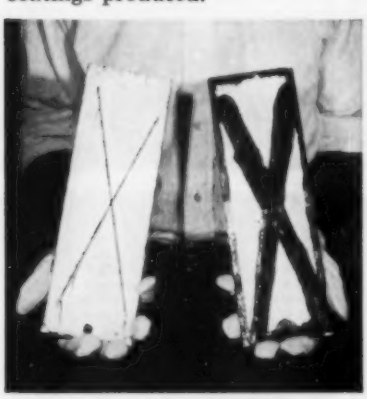
The temperature gauges on the input lines of a typical Cold Bonderite System installation tell the story. 40° to 75° cooler in cleaner, rinse and Bonderite than in the conventional hot phosphating installation.

And all that heat saved translates into dollars saved, because chemical costs are comparable, as is the effective protection of the coatings produced.



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- An appliance manufacturer says the Cold Bonderite System is saving 5¢ per cabinet.
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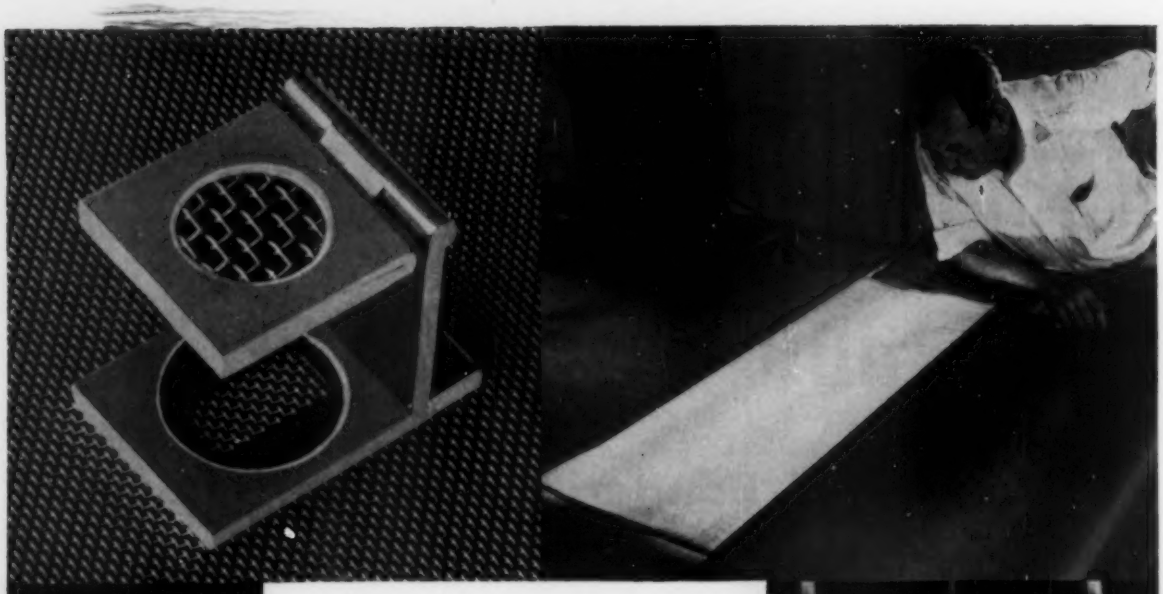

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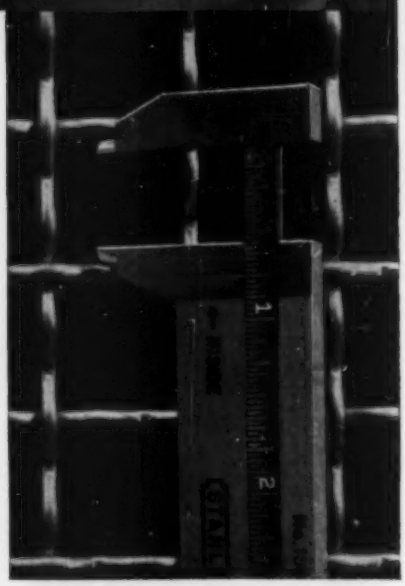
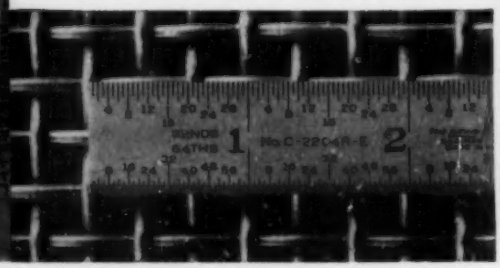
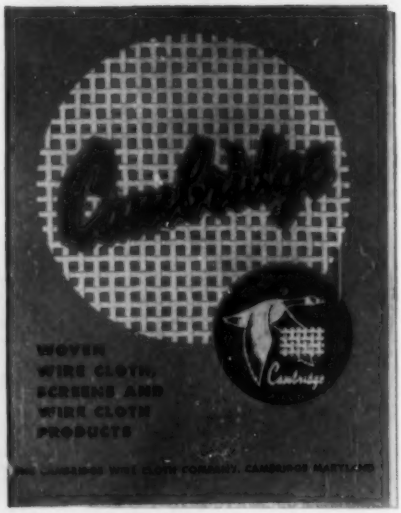
Department P • Cambridge 1, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications







PERSPECTIVES

in design and development . . .

The Federal R&D Budget

Back in 1940 the Federal Government spent $74 million for scientific research and development. The estimated figure for 1959 is $3.7 billion. The only major interruption in this long, steady increase was in the 1946-1949 period—here expenditures dropped from about $1.6 billion to $800 million. The increase in basic research from fiscal year 1952 to 1959 is 140%, compared with an over-all increase of 78% for R & D.

The current R & D budget (fiscal years 1957, 1958, and 1959) shows a jump in obligations (commitments for future payments) from $3.2 billion in 1957 to an estimated $3.6 billion in 1958 and $3.9 billion in 1959. And, since these figures were released by the National Science Foundation, the President has made several supplemental appropriations which will increase Federal R & D by a substantial amount. For example, the new Advanced Research Projects Agency (ARPA) got $300 million and the Dept of Defense $520 million more.

All these figures include the costs of conducting R & D and adding appropriate facilities. In the three years under study about 90% of the total Federal funds for R & D was spent on conducting research and development, with the remaining 10% spent on plant and equipment.

These estimates do not include, however, the reported expenditures for research and development from production and procurement appropriations which were estimated by the Dept of Defense at $825, $875, and $925 million respectively for 1957, 1958 and 1959. The obligations cited above also include pay and allowances of military personnel in R & D.

By far the biggest consumer of government R & D funds is the Dept of Defense; in 1959 it will take $2.581 billion of the total $3.9 billion. This figure covers the funds administered by the three military departments, plus the ARPA, Weapons Systems Evaluation and the Mutual Weapons Development Program. In 1959 the ARPA will get 17% of the Defense Dept total, the Army 20%, the Navy 27%, and the Air Force 36%.

The Atomic Energy Commission ranks second to the Defense Dept in funds consumed for R & D. For both civilian as well as the military, the AEC has spent in 1957, and will spend in 1958 and 1959, $531 million, $759 million and $675 million respectively. Reason for the decrease in 1959 is the decline in funds for R & D plants.

The National Advisory Committee for Aeronautics, scheduled to get $115 million for its R & D in 1959, has been taken over by the new Aeronautics and Space Administration whose R & D funds will about double those of the NACA.

The National Science Foundation, with a $55-million budget for 1959, makes a total of $3.426 billion. The remaining $483 million obligated for Federal R & D will be used for the most part by these departments: Health, Education and Welfare ($217 million); Agriculture ($115 million); Interior ($54 million); Commerce ($28 million).

Who Does It?

Government R & D is done both inside and outside Federal installations. In 1958, 44% of the work will be done in government labs, 38% in industry or profit organizations; and 15% in educational institutions. Looking at 1959, the figures show that with a reduction to 37% of the research done in its own labs, the government is relying more on outside sources.

—Paul Anderson

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Product Engineering **HORIZONS**

January 5, 1959

99.44% pure isn't enough

Somebody told me, years back, that the traditional "99 and 44/100%" purity of Ivory soap is really just a group of syllables selected for alliteration and euphony by a knowing advertising man; actual purity is much higher. Knowing this makes me float, as Ivory does, over the dark sea of realization that a half percent short of perfection is no longer good enough—not in soap, and certainly not in most metalworking products.

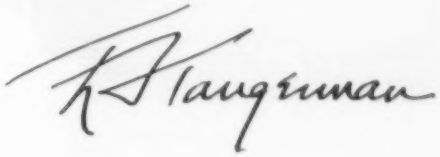
Take the Atlas missile (which put the currently biggest satellite into orbit) for example. Thomas H. Hallowell, the eloquent president of Standard Pressed Steel Company, pointed out a year ago that every one of the 300,000 parts of an Atlas must have a reliability for the mission of 99.99996% if the missile is to be on target nine times out of ten. (This assumes, of course, that failure of one part means failure of the whole.) Thus, as we move steadily toward the greater complexity indicated by 300,000 parts, we move also toward quality standards that are unbelievably high. The combination casts grave doubts on both familiar manufacturing methods and on familiar measuring methods.

The day of the metal product "untouched by human hands," and unmeasured by human eyes, is dawning. Frank Stearns, chief engineer of Split Ballbearing, told me recently that he'd just received the customer's print he has been dreading—the one on which every dimension is given in millionths. This means that yesterday's precision processes are tomorrow's roughing cuts, that top-quality materials are no longer good enough, that atmosphere control moves entirely out of the sphere of worker comfort into that of production necessity. Lintproof clothes, dustproof makeup, and surgical cleanliness are only the beginning; there can't be sunlight, cigarette smoke, sneezes or even corners in assembly and inspection, and maybe even in user areas.

Beyond that, all of our familiar measurements and measuring methods approach obsolescence. Current research is in seventh-decimal-place accuracy of measurement with light waves—precision measurement to one ten-millionth inch. According to Louis Polk, president of Sheffield Corporation, the next step is possibly even shorter waves such as X-rays and electron interferometers. These may permit our measuring to one-trillionth inch—twelve decimal places, smaller than the dimensions of an individual atom.

Thus we are approaching the ultimate in physical measurement and manufacture. A part can't be thinner than one layer of molecules. It must increase in width or length by molecular increments. A surface can't be flatter than one face of a crystal lattice.

There lies ahead an age of engineering and manufacturing quality that is beyond the range of human understanding, one in which tolerances and limits will cease to exist. Shades of Eli Whitney and Proctor & Gamble! There'll be no need for such a modifier as "practically" preceding "perfect" or "pure". And "human", with all its implications of frailty and approximation, will be an archaic word, at least in engineering design.



POWERED SPINNING...

Important development in metal forming

Built-in "feel" and hydraulic power—they meet growing needs for larger and heavier parts in shapes most easily made by spinning.

Heavy steel nose cone and afterbody for missile is spun from welded preforms

About the pictures . . .

Arnold Hildebrandt, the picture-conscious product sales manager for Metal Spinning Div of Phoenix Products Co, planned and produced this pictorial essay to present this brand-new development in an old art.

METAL SPINNING IS AN ART . . .

Metal spinning is an ancient method of metal forming, presumably adapted from the potter's wheel and, until recently, largely dependent on human limitations of skill and muscular power. Skilled manipulation of the metal can exercise considerable control over the thickness throughout the section. For certain ranges of simple

. . . old as the potter's wheel. Long before presses were available, common household articles were produced by spinning, with size and thickness limited by the skill and strength of the

WITH POWERED SPINNING

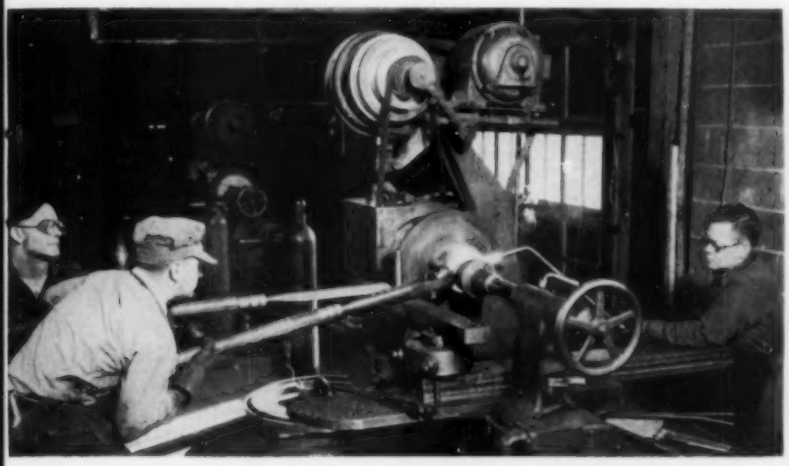
Fan shroud, 13 ft dia, spun from steel 0.076 in. thick

These larger and heavier parts were produced by Metal Spinning Div of Phoenix Products Co on its Powerspin machine (shown on the cover of this issue). Wall thickness is controlled by manipulation of the spinning tool; inside dimensions are established by wood or metal block.

Hemispherical pressure-vessel head 36 in. dia, spun from 5052 aluminum 1⅛ in. thick

conical shapes, the process has been mechanized to "shear-spin" much larger and heavier sections with reproducible precision tolerances. (Some new developments in this equipment are presented in the next article). An inherent characteristic of the process is thinning of the wall in proportion to the sine of the cone angle.

CONTINUED ON NEXT PAGE . . .

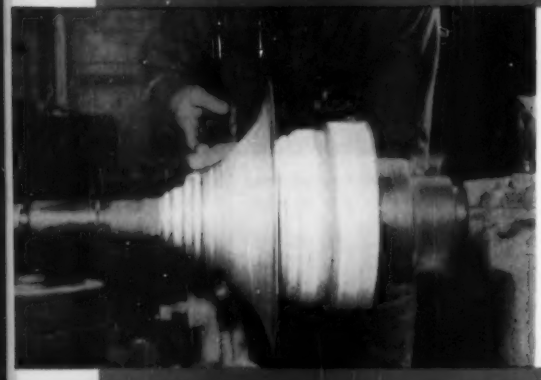


spinner. On heavier pieces you put more men to work. It was an art handed down from father to son, little changed from antiquity other than in the means for powering the spindle.

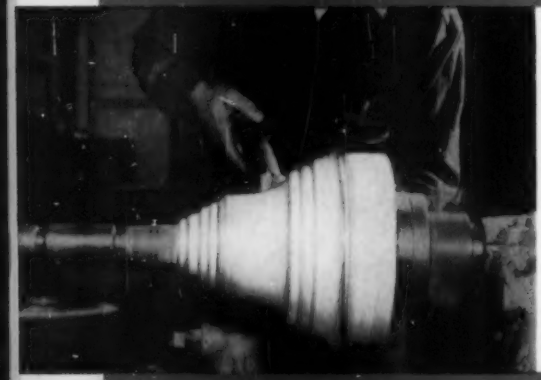
HERE IS THE MANUAL SPINNING PROCESS . . .

1 Flat blank is clamped to wood block.

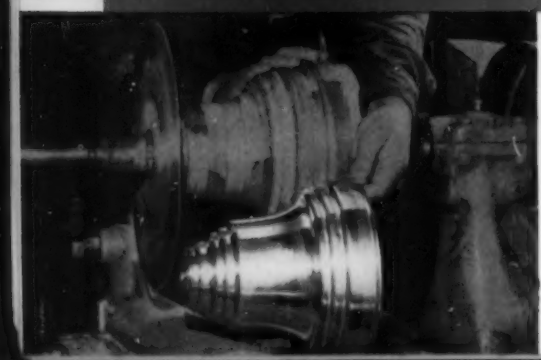
2 Pressure is applied with "friction" tool.



3 Metal is worked from center to edge and back.

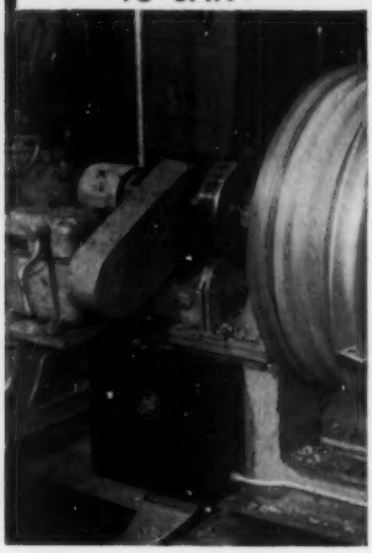


4 Blank now hugs the block as edge is formed . . .



5 And becomes a finished lighting fixture.

TO SPIN



But the broad range of forming by hand spinning has traditionally been limited in size of part and wall thickness by the muscular power of a skilled artisan. Compound tools with a roller, sometimes with two or three men on the lever and another with a torch, could at times turn out larger and heavier pieces—but not economically.

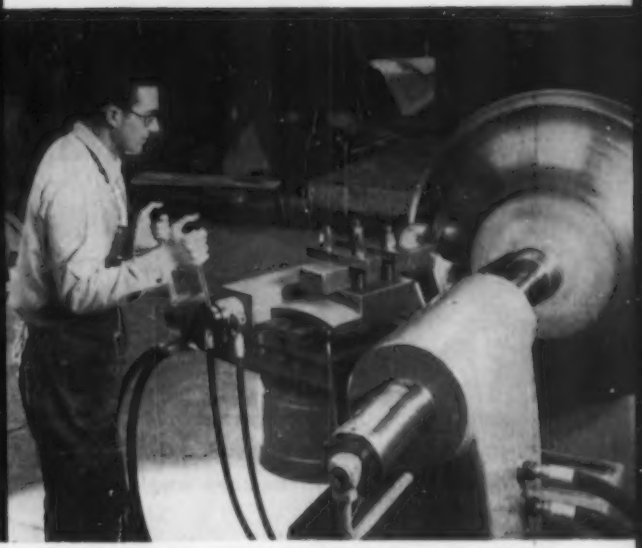
In one effort to add power to the spinner's skill, a machine developed in Germany provides hydraulic power for longitudinal and lateral movement of a roller duplicating manual movements, but the controls require manipulations much different than for manual tools, and the training and experience of the skilled spinner is lost.

To preserve the skill of the metal spinner and the flexibility of spinning, a power source was needed that not only duplicated manual movements, but also gave a sense of "feel." This has been done in the powered spinning lathe shown here and on the cover. Through power servos with "feel" feedback, a skilled spinner can now produce large, heavy and intricate forms with reentrant sections, controlling metal thickness by manipulation. He can spin thick sections of large diameter--15-ft-dia aluminimum $\frac{1}{2}$ in. thick; 5-ft-dia stainless $\frac{1}{4}$ in. thick. High-strength alloys such as 4340 steel, and titanium, molybdenum and zirconium can be shaped.

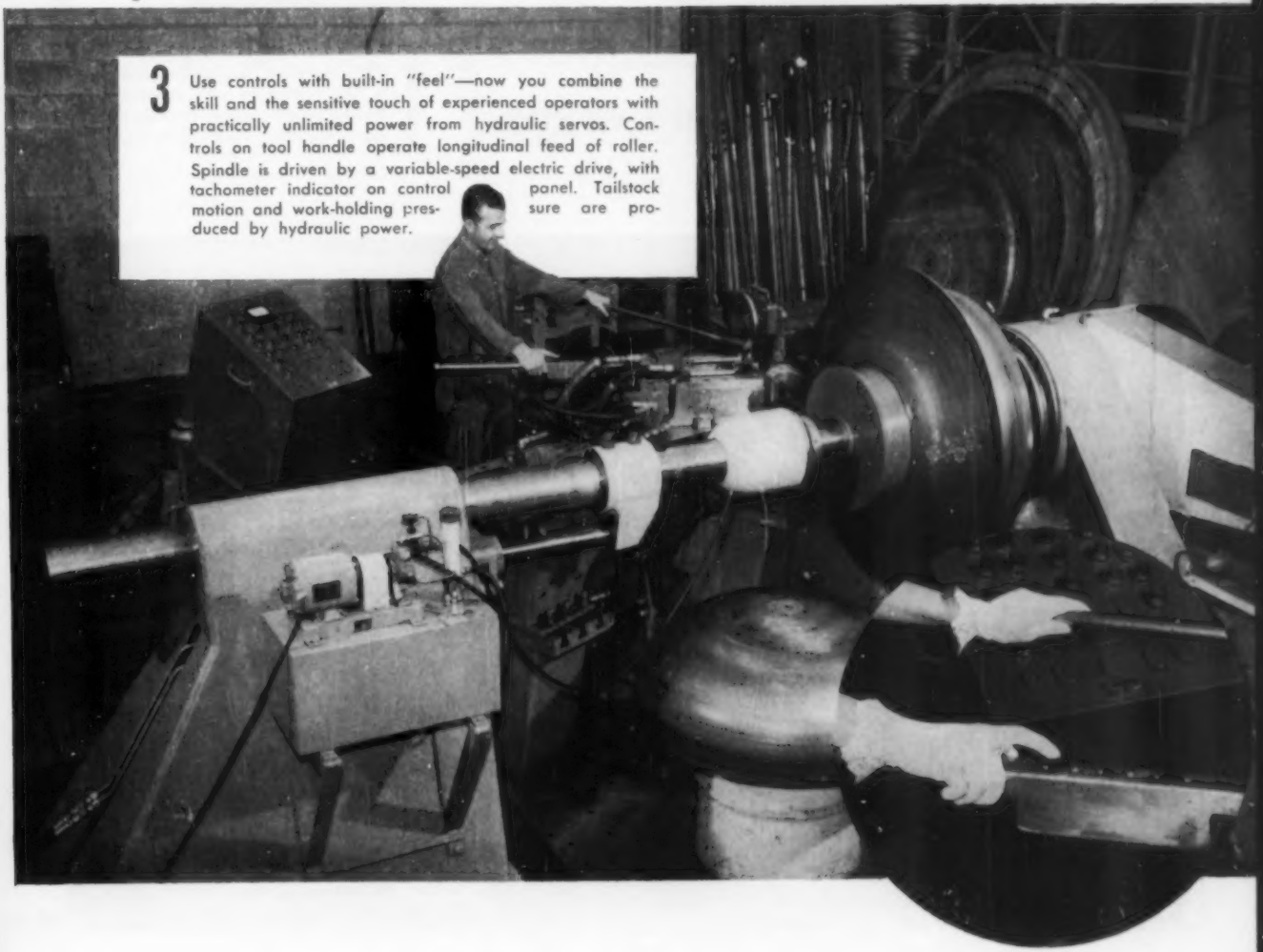
For recent developments in automatic spinning of conical shapes, turn page.

LARGER, HEAVIER PARTS . . .

1 Multiply muscular effort with levers, but this has some very practical limitations.



2 Push the roller with hydraulic cylinders, but this requires a new kind of skill



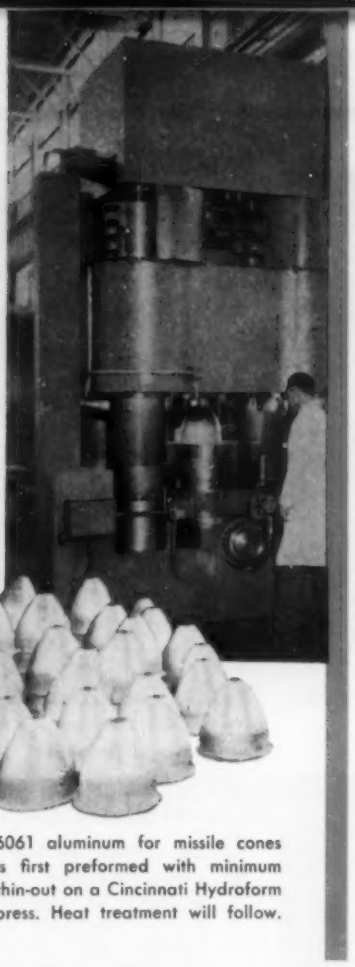
3 Use controls with built-in "feel"—now you combine the skill and the sensitive touch of experienced operators with practically unlimited power from hydraulic servos. Controls on tool handle operate longitudinal feed of roller. Spindle is driven by a variable-speed electric drive, with tachometer indicator on control panel. Tailstock motion and work-holding pressure are produced by hydraulic power.

AUTOMATIC SPINNING

FOR CONICAL SHAPES

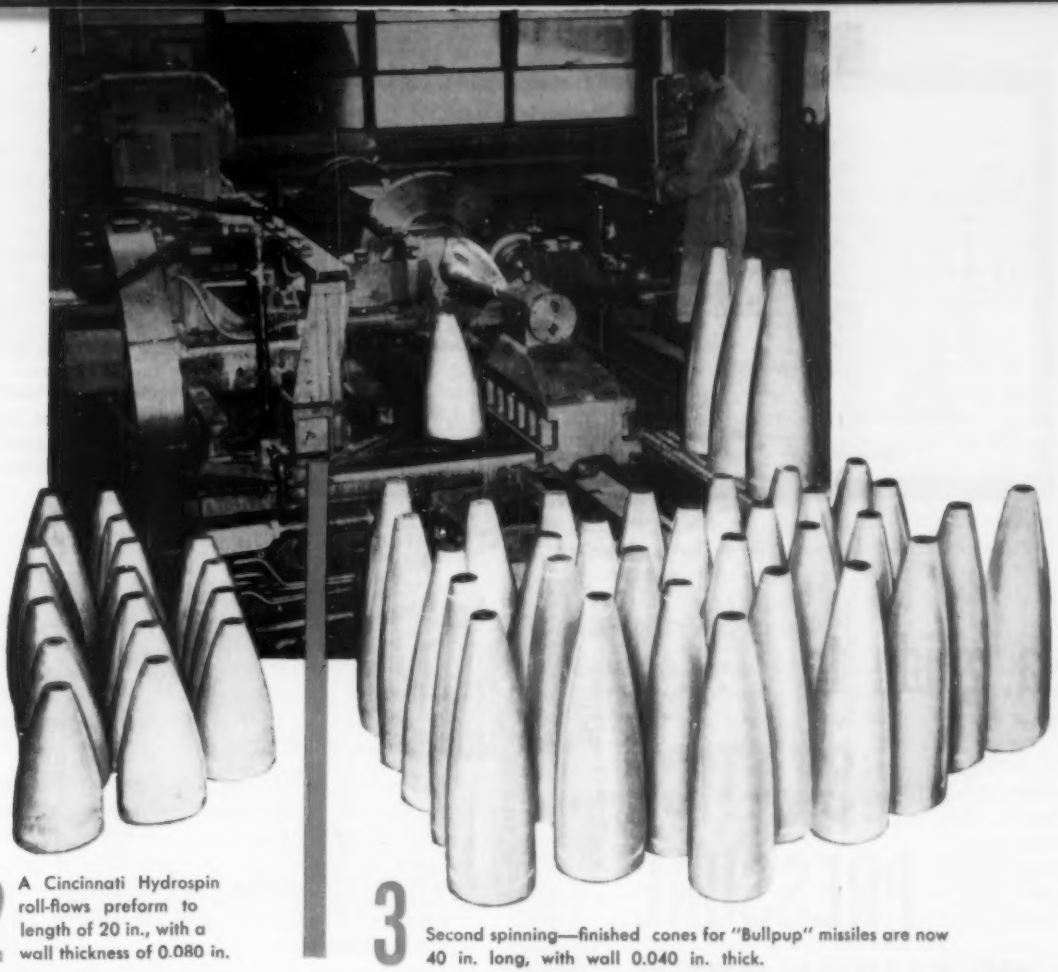
Powered rollers under tracer control "shear-spin" conical shapes with wall thickness proportional to sine of the cone angle.

For certain ranges of conical shapes, the process has been mechanized to shear-spin much larger and heavier sections with reproducible precision tolerances. Range of form is extended by starting with a press-formed part or by successive shear-spinning operations. The method has recently been further mechanized by design of a vertical-spindle machine—below, and on the cover—with dual rollers and hydraulic tracer control.



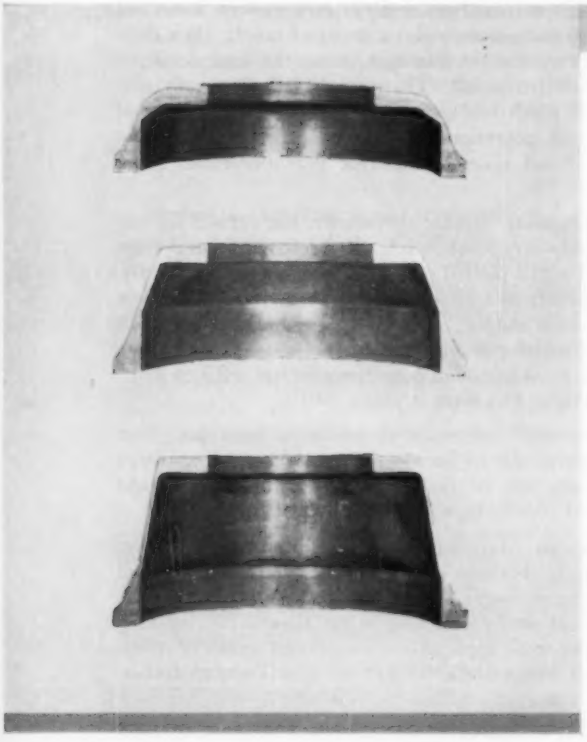
1 6061 aluminum for missile cones is first preformed with minimum thin-out on a Cincinnati Hydroform press. Heat treatment will follow.

DRAWING PLUS SPINNING—IN THREE STEPS



2 A Cincinnati Hydrospin roll-flows preform to length of 20 in., with a wall thickness of 0.080 in.

3 Second spinning—finished cones for "Bullpup" missiles are now 40 in. long, with wall 0.040 in. thick.



FORGING PLUS MECHANIZED SPINNING

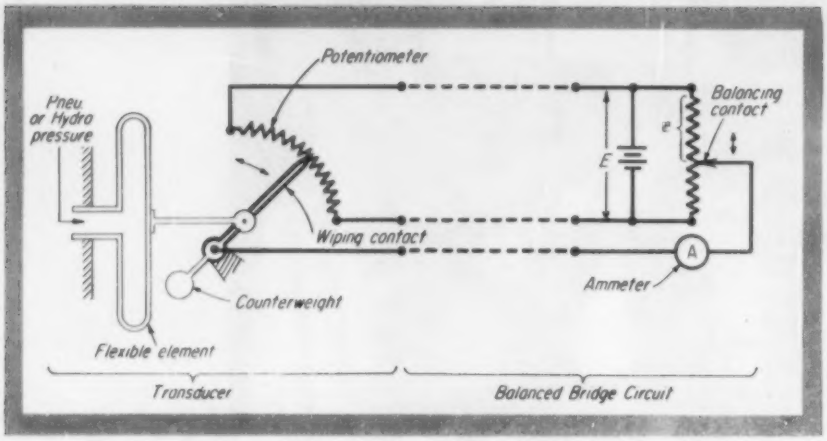
This alloy steel motor-mount starts as a machined forging and is finished in two power-spinning operations.

New Lodge & Shipley vertical "Flotum" machine, far left, with dual rollers under automatic hydraulic tracer-control, produces conical parts automatically. A thickness compensator automatically sets templet position to keep blank flat during spinning operation. Compensator also responds to changes in tool position caused by temperature changes.

In operation, blank is placed in position manually or automatically and cycle started; tailstock spindle moves down to clamp blank on mandrel; carriage moves under rapid traverse until rollers contact blank and then proceed at selected feed speed; hydraulic tracers control roller slides to flow blank to shape of mandrel; at end of feed, carriage, roller slides and tailstock retract, and spindle is braked to a stop. As carriage retracts, part is stripped from mandrel.

EDITOR'S NOTE:

Earlier developments in power spinning were reported in "Power Spinning Conical and Tubular Parts," Aug '56, p 135, giving the advantages and limitations over other metalworking processes, and design data on tolerances, properties, finishes and cost comparisons.



Typical fluid-pressure transducer . . .

has diaphragm or equivalent flexible element that responds to change in pressure level by moving the wiper arm of a potentiometer. A balancing contact in bridge circuit can be moved to give "null" (zero current) reading at the ammeter. Resulting voltage ratio e/E (measured with sensitive voltmeter) is proportional to pressure.

a guide to . . . STATIC-PRESSURE TRANSDUCERS that have diaphragm, bellows or bourdon pressure cells

They sense pressure directly and continuously, as simple bourdon pressure-gages do, and convert the resulting movement or position of the pressure element into electrical units. "Static" here means low-frequency response—less than 4 cps. A future article, on piezoelectric transducers, will cover higher frequencies.

H D NUNN, *Daystrom Inc*

Even before evaluating the available types of pressure transducers, it is necessary to define and understand the performance characteristics desired. The language of the instrumentation engineer looks simple, but is not always easy to understand. Certain concise terms represent more lengthy descriptions. Here are a few samples:

Range—The useful pressure range in which a transducer operates satisfactorily. Bourdon-type elements are good for extremely high range—some to 10,000 psi. Diaphragms and bellows can be more sensitive. Range of zero to 4 in. of water is available in some diaphragm types.

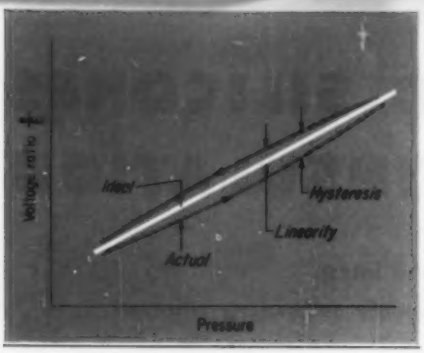
Linearity—If response follows the ideal straight line—not usually possible—then linearity is zero and perfect.

There are two choices of linearity specifications: (1) **terminal linearity**—deviation is measured directly from the so-called ideal line; and (2) **independent linearity**—the manufacturer may plot a series of points, then draw an arbitrary straight line that shows the least deviation of any plotted points. The second method, usually adequate, is much less expensive. Independent linearity of wirewound potentiometers will probably be ± 0.5 to 1.5% of full scale; of film-type potentiometers, better than ±0.7%.

Repeatability—Similar to linearity, but defined for one point only—any point desired. It is referred to an average curve of actual plotted points taken in one direction only. Repeatability of a pressure transducer is the difference in voltage-ratio output, at a given pressure, between this average curve and the farthest anticipated point from this curve. Wirewound potentiometer has ±0.3 to 0.8% repeatability; film-type, ± about 0.03%.

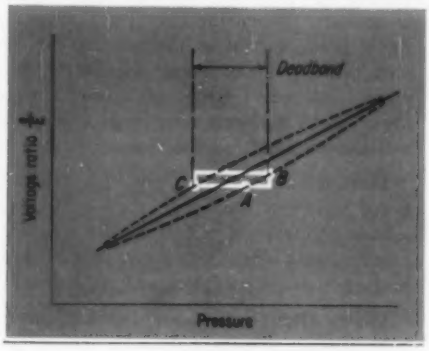
Conformity—Adherence to nonlinear functions. It is otherwise similar to linearity. Corrections for linearity or conformity can be built into an instrument, but add time and cost to manufacture.

Hysteresis—Maximum difference, measured in voltage-ratio units, between plotted curves of increasing and decreasing pressures. Typical values are: 0.4 to 1% for wirewound potentiometers; better than 0.2% for film-type. For some applications, continuous moderate vibration will reduce static friction and give lower hysteresis.



Linearity and hysteresis . . .

introduce error so transducer response is never ideal. Errors are measured in voltage-ratio units at the bridge circuit. Actual voltage-ratio lags behind ideal value whether pressure is increasing or decreasing. A manufacturer may limit guarantee to linearity in one direction only, unless specifications carefully ask for two.



The deadband . . .

is a measure of the minimum pressure change needed to give a discernible change in voltage-ratio output. These three steps give its value: (1) Note voltage ratio at any point *A*; (2) increase pressure until discernible voltage-ratio increase is noted at *B*; (3) decrease pressure until voltage ratio returns to first value. This required pressure decrease from *B* to *C* is called deadband.

Resolution–Smallest change in pressure that gives discernable change in voltage ratio output. For wirewound potentiometers and other discrete-step instruments, percent total length of the step defines the resolution. A simple 50-turn wirewound potentiometer has a resolution of one turn–which is $\frac{1}{50}$ or 2% of total turns. This can also be considered 2% of total pressure change. But care must be taken not to specify too fine a wire, or wires too close together–otherwise manufacturing problems become difficult. Typical available resolution is about 0.05 to 0.4%.

Infinitely small resolution is inherent with metal-film-type potentiometers because they have no turns of wire. But limitations are still found in the mechanical elements of the transducer. "Threshold" is a term sometimes chosen to define over-all resolution–of potentiometer, linkages, and diaphragm or bellows.

Deadband–This is graphically demonstrated in lower sketch. Expressed another way, input pressure may vary within the deadband without any noticeable change in output.

Tolerance, sensitivity, accuracy–These terms are not as specific as the rest. Sensitivity is a combination of resolution and deadband. Accuracy includes everything except resolution, and is often specified by drawing two parallel lines above and below the ideal–all data points are expected to fall between them. Tolerance means any permissable deviation from the ideal, and includes all previous terms.

A danger in simply specifying accuracy is that the slope of the plotted data can easily vary 10% and yet be within the parallel bands. Unusual ambient temperatures for barometric instruments with trapped air volumes, may throw all points out of range, yet maintain perfect linearity and slope. One solution is to specify accuracy plus one other characteristic–such as slope–considered important to the application. To be sure that requirements do not conflict, plot the extremes of each specification on the same graph.

What about Rough Service?

Acceleration can adversely affect readings, but it can be handled in several ways. The counterweight method illustrated at top of previous page balances acceleration by reducing unbalanced moments, but compromise is necessary. In this example, with shock or vibration in the vertical plane, the wiping-contact assembly gets little loading from connecting link, and pressure cell because effective pivot point is near the cell. The counterweight is therefore a little too heavy. However, in the horizontal plane, acceleration-forces from the cell and connecting link are transmitted more readily to the wiping contacts, and the counterweight is a little too light.

Additional resistance to acceleration is obtained with stiffer springs and bellows, and greater friction between surfaces of wiping contacts and potentiometer. Sensitivity suffers with each effort to reduce effects of acceleration, however. Therefore, shock or vibration resistance should be specified as low as possible consistent with actual expected duty. Tolerances are usually given in voltage-ratio error vs units of gravity, g.

High proof pressure will also reduce sensitivity because stronger, stiffer pressure-cell walls are needed.

Overtravel can be prevented with mechanical stops, but in many instances lower stresses will occur if free movement with reasonable overtravel is allowed. A constant-electrical-resistance extension to the potentiometer resistance element may give the answer.

EDITOR'S NOTE: For previous articles helpful to design in this field, see:

"Pressure Transducers," Jan '54, p 174, thoroughly compares strain gage, capacitance, crystal and reluctance systems under headings of response, hysteresis, construction and so forth; "Pressure-sensitive Material," Sept 16 '58, p 106, provides engineering data on new pressure cells made from intermetallic resins that promise low-cost transducers with high response.

Electrical circuits at the output are also important to transducer applications: See "Wheatstone Bridge Charts," Sept '54, p 109, which solves Thevenin's theorem for balanced bridge circuits.

Resin-based foam cradles electronic parts.

NEW FOAMED SILICONES GIVE HI-TEMP INSULATION

Here are first data on the latest rigid, semirigid, and flexible self-curing silicones.

DONALD E WEYER, *Product Engineering Laboratories, Dow Corning Corp*

New rigid and semirigid silicone resin foams have just come out of Dow Corning's laboratory to extend the high-temperature insulation field. Besides their inherent resistance to heat deterioration, they offer:

- Self-foaming properties at room temperature.
- Low pressures needed for foaming.
- Low density that reduces weight of the assembly.
- Low thermal conductivity and self-extinguishing characteristics.

Of the new resin foams, two are now available on a limited basis. Stable up to 650 F, both can stand higher temperatures for limited periods. One is a rigid foam with density of 4 to 5 lb per cu ft; the second, with same density, is semirigid and less brittle.

Ingredients are a silicone resin and an additive. To get uniform cell structure, these must be blended with high-speed mixers. Foaming starts immediately after the mixing, so the material must be quickly cast into molds or foamed in place. In the course of its frothing the combination gives off some heat but usually not enough to raise temperature above 110 F. Expansion of the soft foam is complete in 15 minutes but for maximum strength it should cure for 24 hours.

Putting the Foams to Work

Self-foaming allows casting in place to protect complicated assemblies. The low viscosity of the foaming mixture helps it flow around odd shapes, through narrow crevices and small holes. This saves labor—older foaming silicones, by contrast, are cast into molds, then fitted in place. Also, when a coating of insulation is needed, the new material can be sprayed or dipped.

Cold-foaming and curing gives these foams a temperature advantage. Older silicones have to be heated past 320 F to start foaming, so cannot be used where heat will damage such parts as soldered connections and transistors. Now these parts can safely be potted in foam that insulates them against heated environments.

Low-pressure foaming protects fragile parts. It also allows using a mold of thin and cheap material—cardboard, glass cloth, asbestos paper, or even aluminum foil. The foams conform to shape, so will not distort thin molds. Such molds should be left as a protective skin because the foaming mixture adheres unless special parting agents are used. Whenever the foam surface lacks such a skin, it can be protected against abrasion with hot sealers or rubberized paints.

Low density—4 to 5 lb per cu ft—gives these foams their light weight and high thermal insulation qualities. This density is uniform—the material has been foamed up to 6 feet with only slight variation from top to bottom. When the cavity or mold is too large for a single pour, successive batches can be cast on top of each other. (Three hours should be allowed between pours.) Lower density, of course, lowers mechanical strength. With lower compressive values, silicone foams lack the strength and toughness of other plastics.

Heat resistance is slightly lower than with conventional silicones. Although their maximum continuous-service temperature is 650 F, the new foams gradually lose flexibility when heated over 500 F. For intermittent heating, top operating temperature is 700 F.

Water absorption is low because these silicones are hydrophobic. However, only 40% of the cells are closed so the foams are not completely moisture-resistant. Therefore, though they retain flexibility to −65 F, they are unsuitable for insulating at low temperatures, where their pore structure will eventually soak up moisture—with an increase in thermal conductivity and lowering of electrical resistance.

Thermal conductivity of both rigid and semirigid resin varieties is 0.281 btu/hr/sq ft/deg F per in., comparable with early silicone foams and other foamed plastics in general.

New Rubber Foams

In addition to the resin-based foams discussed above, a series of self-expanding and self-curing silicone rubbers have been developed. Methods of handling are similar to those for the resin foams, but the foaming time is much shorter—complete expansion and set occur within 4 minutes. Molded foamed parts which can be removed in 5 minutes have approximately 80% of their ultimate strength. With expanded densities from 5 to 13 lb/cu ft, these foams retain flexibility from −65 to 500 F. Top continuous operating temperature, however, is 400 F. Unlike the resin-based foams, these are naturally flammable, but can be made self-extinguishing with suitable additives. Fabrication is by molding to shape with or without pressure, knife or dip-coating, continuous mixing from dispenser, or casting in place. Like the resin-based foams, these are open-cell structures, though developments on closed-cell rubber foams look promising.

Your Library on Plastics is Here

As indicated by the foregoing article, the plastics field doesn't stand still. And our pages have furnished a continuous record of progress—articles on what is new in the field, along with roundups and guides to best design. For reference, such articles are arranged below in three convenient categories:

Materials—subdivided, in turn, into: *rigid plastics* for structural and electrical uses; *flexible elastomers* for sealing and abrasion resistance.

Processes—how design is affected by the ways the plastics are turned into engineering parts.

Finishes and Coatings—how design can use these plastics as durable coatings; and also how to provide a metal finish for plastic parts.

Materials: Rigid Plastics

"Plastics for Structural Uses," June '56, p 67, classifies their load-carrying ability, chemical and temperature resistance, and dimensional stability. The latest three—Delrin, Lexan and Pro-fax—are compared with nylon in "Three New Rigid Thermoplastics," Sep 29 '58, p 36, for their mechanical, thermal and electrical properties. "Plastics . . . Properties and Applications," Mid-Oct '57 p C28, correlates trade names with chemical family; gives properties, typical applications, and manufacturer's name. "New Materials by Irradiation," Apr '57 p 172, includes "How Plastics Change by Irradiation" and "Grafted Plastics by Irradiation." To specify plastics for high-impact applications see "How to Choose a Tough Rigid Thermoplastic," Nov '56, p 167.

"Resins for Reinforced Plastics," May '56, p 198, evaluates the major classes of resins for reinforced moldings or laminates. Some of these reinforced plastics make corrosion-resistant springs. "Plastic Springs," June '56, p 183, gives elastic properties of reinforced helical springs.

Rigid foams to back up thin structures are covered in "Best Recipe for Urethane Foam," Nov 10 '58, p 86. They are also compared with other foamed plastics in "Sandwich Core Materials," Jan 20 '58, p 70.

"Designing with Nylon," Mid-Oct '57, p C11, gives engineering properties and how to use them in gear and bearing design. Nylon 11, with its resistance to moisture absorption, retains mechanical properties and dimenisonal stability; readers learned about it in "New Nylon from France," Dec 23 '57, p 76. Nylon for bearing materials is covered in "Nylon-clad Sleeve Bearings," Mar 3 '58, p 52, and in "Additives Strengthen Sintered Nylon," Sep 15 '58, p 86. "Epoxy Castings," June '57, p 135, can substitute for complex molded parts.

Materials: Flexible Elastomers

For flexibility, capacity to absorb energy, and resistance to wear and abrasion, choose an elastomer. A quick test for narrowing the choice is given in "Picking the Plastics for Abrasion Resistance," Mar 31 '58, p 105. Its table lists specific characteristics of some elastomers and rigid plastics that resist abrasion best. "Cast Urethane Rubber," Sep 16 '57, p 68, describes this hard yet resilient rubber which stands out in resistance to wear.

Elastomers for high-temperature applications are discussed in "Silicone Rubber Sponge," Aug 4 '58, p 54, which tells how better sponging grades, sharper processing controls, and special reinforcing techniques give closer tolerances and decrease dimensional rejects. "Molded Silicone Parts," Apr 14 '58, p 69, gives tips on installing this high-temperature material which may be weak at room temperature; how to design shapes for best service. "Silicone Rubber," Mar '56, p 173, compares various silicone rubbers for their mechanical properties, electrical insulation and chemical resistance. "Properties and Applications of Silicone Rubber," Mid-Oct '57, p C22, brings out differences between silicone rubber, natural rubber, GRS and neoprene. "High-temperature Butyl," Nov 11 '57, p 90, compares improved butyl rubber with five different elastomers.

How to Use Them

After choosing a material, you must then process it into usable parts. To choose the right process, see:

"How to Design Out Cost of Plastic Parts," Oct 14 '57, p 77—a run-down on costly requirements such as heavy walls; charts aid selecting process.

Forming sheet phenolics is discussed in "Post-formed Phenolic Laminate," Feb 17 '58, p 66. "Design Hints for Laminated Parts," Jan '57, p 86, gives best shapes; how laminates carry loads best. "Forming Plastic Sheet," Mid-Sep '58, p D4, describes variation of basic vacuum-forming processes for thermoplastics, and "Vacuum Forming—Where It Stands Today," Dec. 22 '58, p 56, details design of parts by thermoforming.

"Designing with Plastics," Mid-Oct '55, p C19, gives basic rules for designing molded thermoplastic and thermosetting materials. Process limitations when molding phenolics are described in "For Better Phenolic Molded Parts," Sep 1 '58, p 86. "Faster Molding for Rubber Parts," June 23 '58, p 68, describes a high-speed automatic process for consistent dimensional accuracy; tells which materials can be used and how to design parts. "Sprayed Reinforced Plastics," Jan 13 '58, p 17, details low-cost process for making reinforced plastic parts.

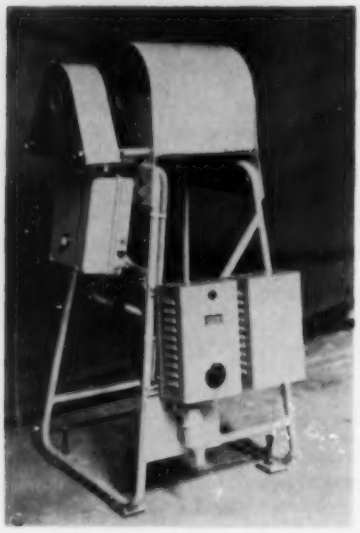
Coatings and Finishes

Plastics that serve as finishes for metals combine protection with color and texture. Pertinent articles include: "Fluidized Plastic Coatings for Corrosion Resistance," Jan '57, p 140, describes powder dip process which provides uniform coatings on intricate parts; helps choose coating materials. "Textured Steel," Mar 17 '58, p 73, "Prepainted Steel," Dec 9 '57, p 99, and "Vinyl Laminate," July '56, p 167, show in color the visual effects of some of these wear- and corrosion-resistant plastic coatings.

How to fabricate such coated steels is given in "Magnetic Welding for Vinyl-clad Steel," Sep 15 '58, p 82. "Mylar, a high-strength Film," July '56, p 187, compares other thin films with Mylar—gaining favor as a protective coating. Metal coatings for plastics and plastic films are discussed in "Vacuum Coating Goes Industrial," Dec 23 '57, p 67, and "Metallizing Plastic Film," Aug '55, p 182.

DESIGN FEATURES

GERMANY

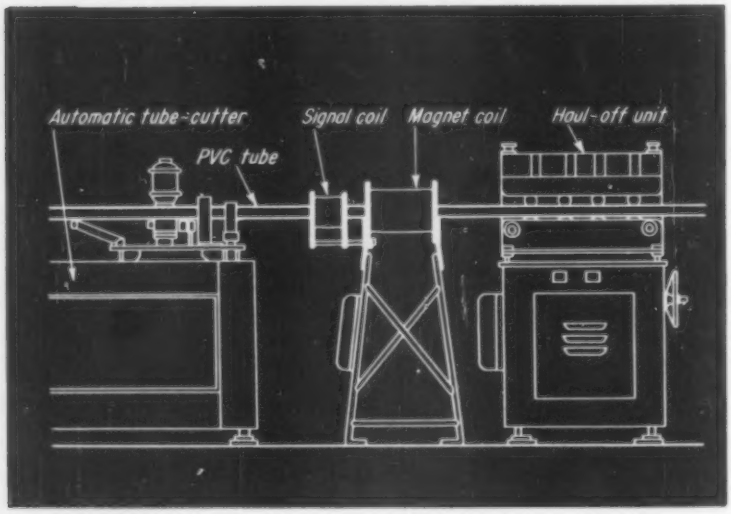


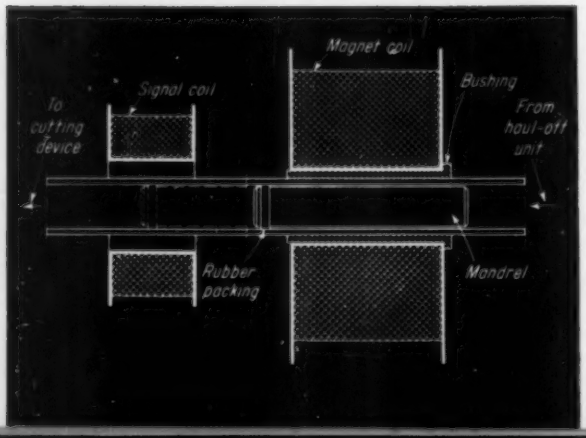
Magnet Checks Tubing Bore

Iron mandrel held by electromagnet checks bore as plastic tubing is extruded. Deformation or ID variations trip signal to halt automatic cutter.

The inspection unit checks rigid PVC tubing up to 2½ in. ID. For smaller-dia tubes an iron bushing corresponding to the desired tube OD is used. Tester and signal device is produced by John Kleinewefers Sohne Machine-works, Krefeld.

Tube tester . . .
is mounted between haul-off unit and automatic cutter. PVC tubing leaving extruder is transported by haul-off unit through tester to automatic cutter where continuous run of tubing is cut to length. Defects in tubing ID trips horn signal for operator to stop cutter.

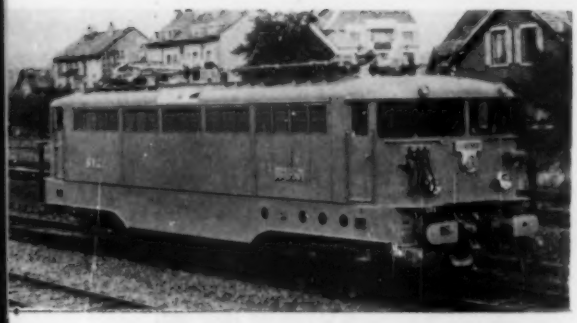




Two coils . . .
are used in tube tester. Magnet coil holds mandrel in place in moving-tube bore. Signal coil is operated when displaced mandrel interrupts its magnetic field, tripping the signal device.

Rubber packing on mandrel is airtight fit for pressure check of tubing. Longer mandrels are used for tubing with smaller ID to produce same magnetic holding force. Bushing is also changed for various tubing ID's.

Tester could be used for any nonferrous tubing and audio signal device could be replaced by cut-out relay to stop cutter automatically.



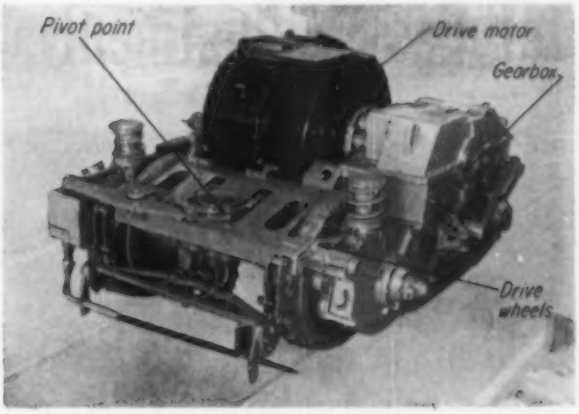
FRANCE

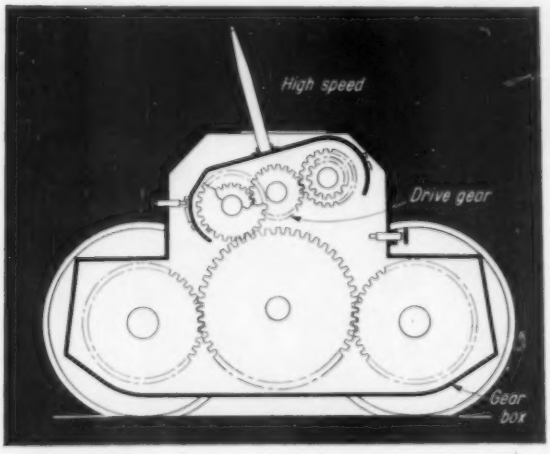
This Locomotive Shifts Gears

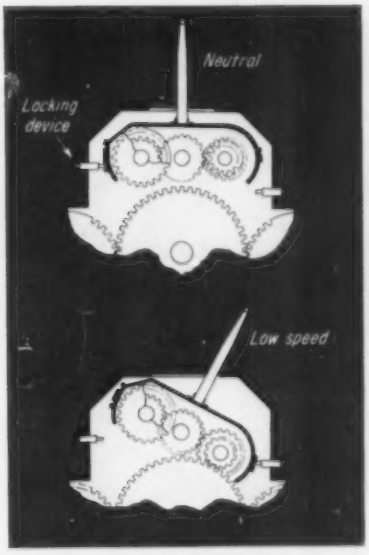
Simple gearshift doubles usefulness of the electrically operated power unit. It will either haul heavy freight or give high-speed passenger service.

Operating on 25,000-v, 50-cycle line current, the 75-ton locomotive is claimed to be the lightest 3500-hp unit ever built. Top speed for passenger service is 94 mph and 56 mph for freight trains; in low gear can haul a 1550-ton train up a 1% grade. Produced by Alsthom, Paris, for French National Railway System.

Motorized bogie . . .
mounts 1100-v dc traction motor above and between the two axles. Two-speed gearbox lies outboard of wheels on one side of bogie. Short wheelbase of bogie makes it possible to mount the main transformer of the locomotive between the bogies in an oil-filled well built into the chassis. Improved adhesion is achieved by locating the pivot points, on which the chassis rides, outside the axles.







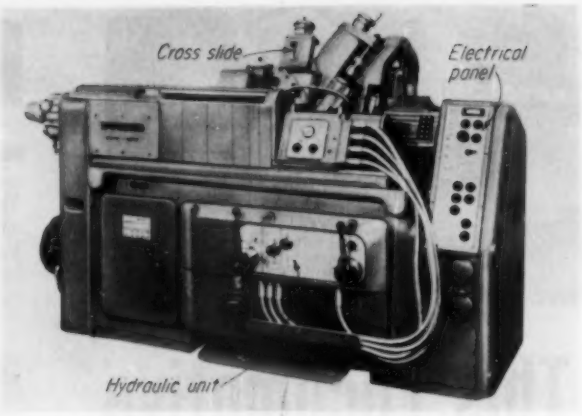
Gear changes . . .
are made by a lever on each bogie which is accessible from the corridor joining the cabs at each end of the locomotive. Three gear positions may be selected: High, Low and Neutral. A mechanical locking device insures that the gears are properly meshed and stay in mesh. Also, an electrical interlock keeps the motor supply circuit open until the locking device is fully engaged. Neutral position permits the locomotive to be towed or dead-headed without stripping gears or damaging electrical equipment. Gear shifts are made by the regular train crew—this requires stopping the train for about 3 minutes.

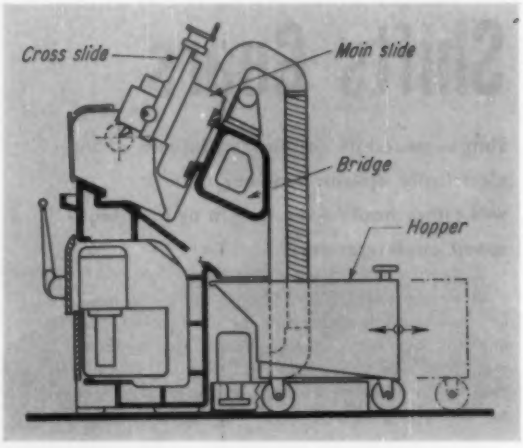
SWITZERLAND

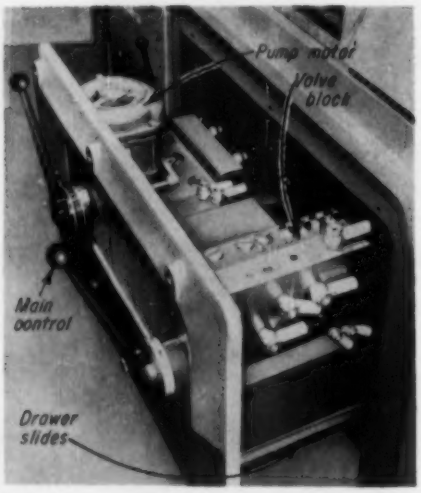
Lathe Packaged for Easy Adjustment

Unit construction of this copying lathe simplifies maintenance and modification to meet needs of a different job. Panels, plug-ins, and pullouts are used for improving accessibility.

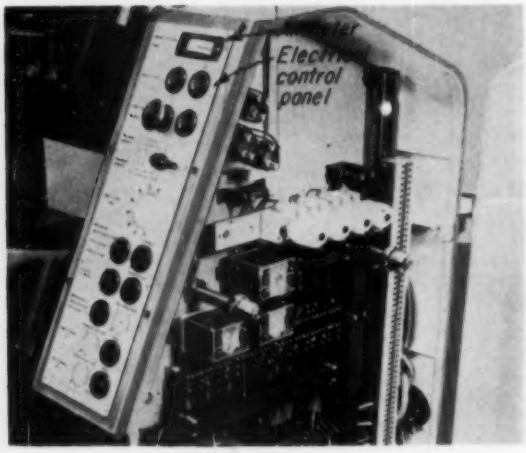
Inclined bed and bridge—on which the cross slide moves—are cast as one piece to avoid joints. Bridge mount of main slide allows chips to tumble down chute to a wheeled chip hopper. Hydraulic copying lathe, Dubied 517/500, was developed by Edouard Dubied & Co, Neuchatel.



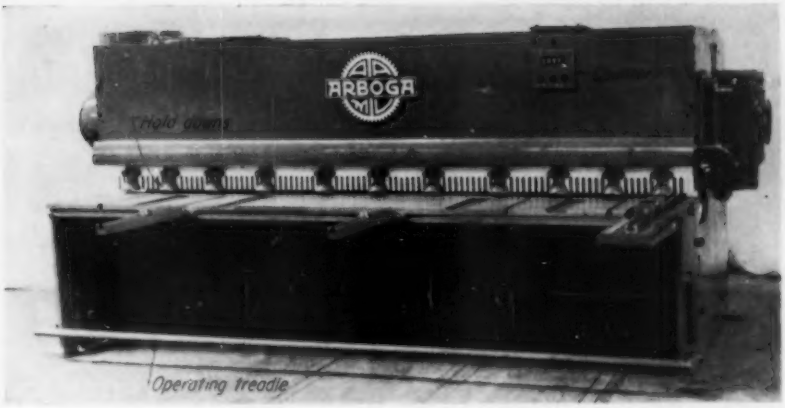




Hydraulic unit . . .
with oil tank, submerged pump-motor unit and valve block mounted on drawer slides is fitted in the front of machine base. Connections are with flexible tubing—when drawer is pulled out for adjustment lathe can continue operating. Space between motor and valve block allows additional valve blocks for controlling hydraulic clamping devices and plunge cutters. After setting up, all movements are controlled by the single main-control lever.



Electric components . . .
are mounted in a fully enclosed dustproofed housing on right-hand side of machine. All electrical controls are mounted on a control panel at front of the housing. Ammeter at top of panel indicates spindle loads. Swingout control panel and hinged side panel provide easy access to all connections and components for adjustment and modification.

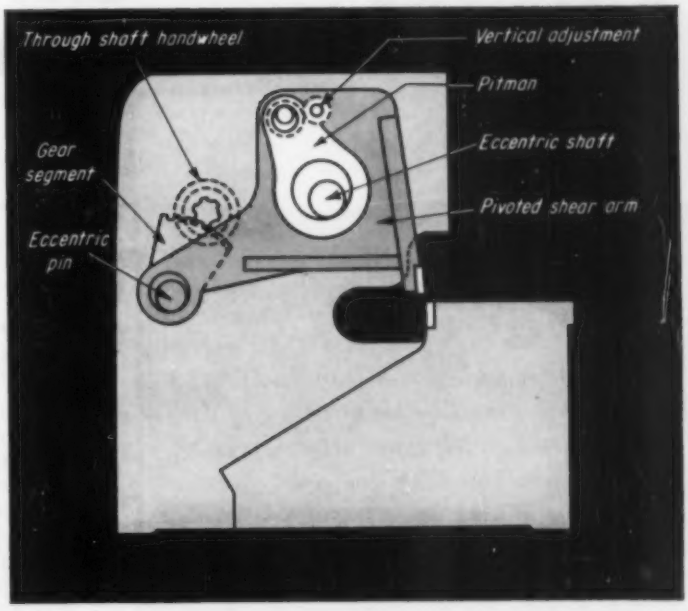


SWEDEN

Swinging Shear Slices Sheet Squarely

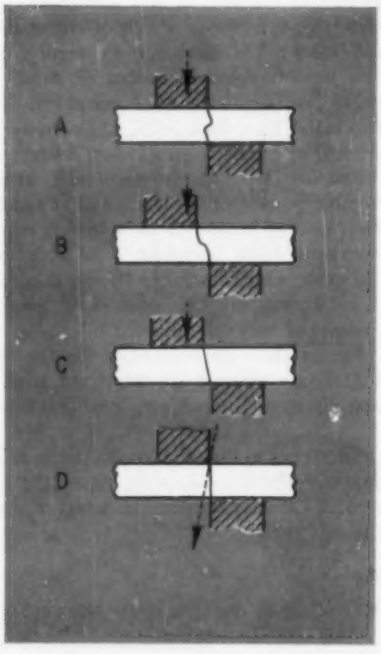
Pivoted shear blade eliminates guides and the attendant maintenance. Pushbutton adjustment of knife clearance speeds production setup.

The counter has three pushbuttons that control setting of blade clearance; the same counter indicates clearance. This power shear, DPC 25-350, is produced by Aktiebolaget Arboga Mek. Verstad, Arboga.

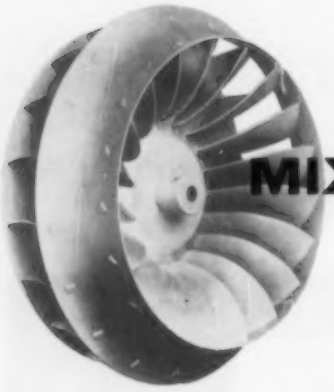


Shear blade . . .
pivots on eccentric pins mounted in frame. By rotating eccentric pins, horizontal clearance between blades can be set for desired clearance. Pins are rotated by gear segments driven by pinions on through-shaft. This shaft is rotated by hand wheel or motor. Motor control is by pushbutton on counter mounted on front of press.

Pitman, operated by eccentric shaft, pulls blade down in arc past lower blade. Vertical clearance between blades is set by rotating eccentric pin connecting pitman arm and shear arm.



Clean cut . . .
requires precise horizontal clearance between shear blades. Insufficient clearance (A) or excessive clearance (B) produces ragged edge. Vertical blade stroke with correct clearance (C) gives clean cut but not square to stockface. Inclined shear stroke with correct clearance (D) followed by pivoted shear blade, gives clean cut square to stockface.



MIXED-FLOW IMPELLERS ENTER AIR-MOVING FIELD

CHARLES A HATHAWAY, *Chief Engineer, The Torrington Mfg Co, Torrington, Conn*

Developed for the air-conditioning field, the mixed-flow impeller outperforms older types where pressures are too high for axial fans and too low for centrifugal blowers. Here are charts and equations for comparing performance, and an analysis of air-conditioning needs.

A new type of fan—the mixed-flow impeller—has been recently developed by the Torrington Mfg Co, that is quite different in air-moving action and appearance from conventional axial and centrifugal types.

The new impeller design performs efficiently and quietly in the range of air flow and static pressure where most air-cooling and heating appliances must operate. It is here where most fans take a drop in efficiency; the pressure being too high for axial and too low for centrifugal fans. Mixed-flow fans, on the other hand, operate at such higher efficiency levels in this range that a significant reduction in noise, size and power requirements is obtainable.

Three Variations in Contour

Conventional air-moving impellers are either axial (propeller fans) or centrifugal (blower wheels), Fig. 1. For example, a room air conditioner, with one impeller at the evaporator and another at the condenser, may use two propeller fans, two blower wheels or one of each.

Propeller fans receive and discharge air axially; centrifugal fans, on the other hand, receive air axially at inlet and discharge radially from their periphery. The terms axial and radial flow then refer, respectively, to type of air discharge of propeller and blower wheel.

The new mixed-flow type has blades which, at the intake edge resemble propeller-fan blades; and at the discharge edge they are centrifugal, as in a blower wheel. Result is a compound blade curvature with both axial and radial components which discharge the air conically.

As designed by Torrington, the mixed-flow impeller has 19 blades, mounted between a curved inlet ring and a back plate. Pressure-flow characteristics for the four sizes shown, Fig. 2, are uniform in shape and without the stall-recession dip usually found with axial and centrifugal types.

Though the differences in direction of discharge define the physical action of the three impeller types, the performance differences are best described in terms of static efficiency and specific speed.

Static Efficiency

Static efficiency of an air impeller is the ratio between static-pressure power and horsepower input. It can be

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computed in percent from the equation:

$$\eta_s = \frac{Qp_s}{63.6\ P_i}$$

where Q = air flow rate in cu ft per minute (cfm), p_s = static pressure in inches of water, and P_i = impeller input power in horsepower.

Inefficient impeller operation is usually accompanied by excessive noise because a greater amount of energy is dissipated in air turbulence. Although total sound energy (including that which is irritating to the ear and is called noise) is only a small part of the unused power, improved impeller efficiency and quieter operation usually go together.

Higher static efficiency, of course, indicates one of two things about the motor: either a lower horsepower for the same flow output, or a greater output for the same power input. Lower power, in turn, allows using either a smaller motor or reduced motor speed (dropping from 1750 rpm to 1160 rpm, for example). The lower speed causes less noise but is economical only if it remains within the standard range.

Specific Speed

A convenient parameter for combining the major variables that affect the selection of an impeller is the specific speed, whose equation is:

$$N_s = \frac{NQ^{1/2}}{p_s^{3/4}} \qquad (2)$$

where N = impeller motor speed in rpm and Q and p_s are either the flow rate and pressure that an impeller is capable of delivering at a particular speed, or that a flow system requires for desired performance.

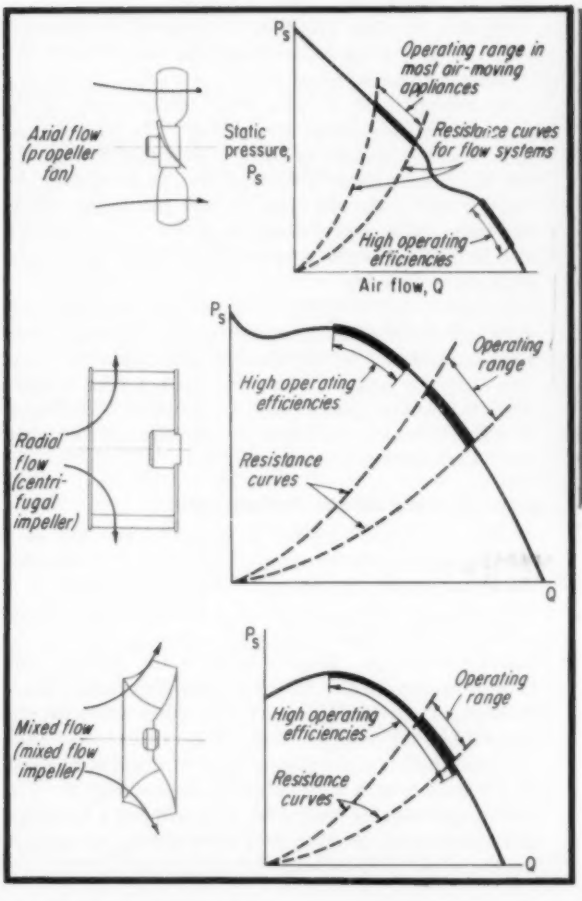
Specific speed should not be confused with the rotational speed of the fan, also in rpm.

Operating Ranges of Fans

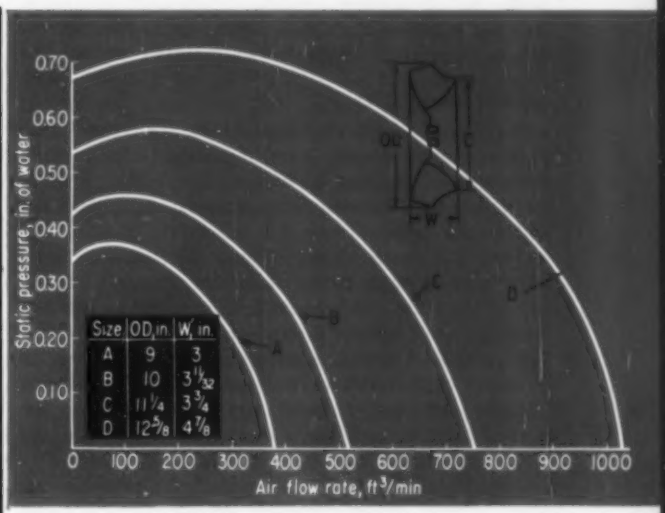
Static pressure and air flow are closely associated. Plotting one against the other gives performance curve of the fan, such as those in Fig. 1. Each fan has its own curve and can be operated at any point on this curve.

Exact operating point, however, is determined by the resistance of the system (baffles, air-flow configuration). The fan will automatically operate at the intersection of the system resistance curve and performance curve.

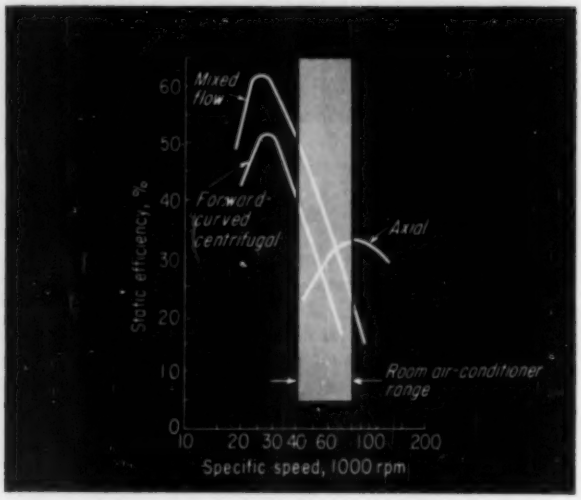
(Continued, next page)



1 Flow paths . . .
and performance curves of three types of fans. Mixed-flow is designed to operate within its high efficiency range.



2 Mixed-flow impeller . . .
(Torrington, type HE) shows these performance curves for four sizes ranging from 9-in. to 12⅝-in. outer diameter.



3. Specific speeds . . .
of 40,000 to 80,000 rpm are the usual range for room air-conditioner applications. Although most fans do not operate at their best here, mixed-flow type offers highest efficiency.

4. Pressure, efficiency and power requirements . . .
of the three fan types as tested with and without housings. Centrifugals are greatly affected by housing configuration—in contrast to mixed-flow fans which give good performance even without a housing.

Each fan also has a range where its efficiency is high. The curves in Fig. 1 do not represent actual cases, but give the operating range for most air-moving appliances such as air conditioners. It can be seen that only mixed-flow fans operate within the high-efficiency range. The propeller fan, inherently a low-pressure impeller, has its highest operating efficiencies just below the stall recession dip, while highest efficiencies for the blower wheel are at relatively high pressures.

Specific-speed Curves

Any fan of a particular type will have a certain efficiency at a given specific speed regardless of size. Thus each type of fan can be defined by plotting a single curve showing the relationship between static efficiency and specific speed.

The three curves in Fig. 3 show the measured static efficiencies of three comparable sizes of axial, forward-curved centrifugal and mixed-flow impellers in standard housings (for centrifugal and mixed-flow) or orifices (for axial). Although efficiency and specific-speed coordinates of the peak of each curve shift for different impeller sizes and proportions, the solid curves are characteristic of each impeller type, and thus do not depend on actual dimensions.

The "room air-conditioner range" indicated in the chart between specific speeds of 40,000 and 80,000 rpm was computed from Eq (2) by using values of flow rate, Q, static pressure p_s and motor speed N that are normally required in room air conditioners and other air-moving appliances. Specific limitations on each of these factors are:

Flow rate—determined by established heat-transfer rates and unit performance required for appliance markets.

Static pressure—determined by air-path configuration, coil resistance, filters, louvers, and other elements in the flow system.

Motor speed—determined by choice of standard four- and six-pole shaded-pole and split-capacitor motors.

The curves show that the mixed-flow impeller operates at a higher static efficiency than the comparable forward-curved centrifugal impeller throughout the appliance range, and higher than the axial impeller through most of the appliance range. Thus, at 60,000 rpm, efficiency of the mixed-flow impeller is 35%, while the axial is 31% and the centrifugal is 23%.

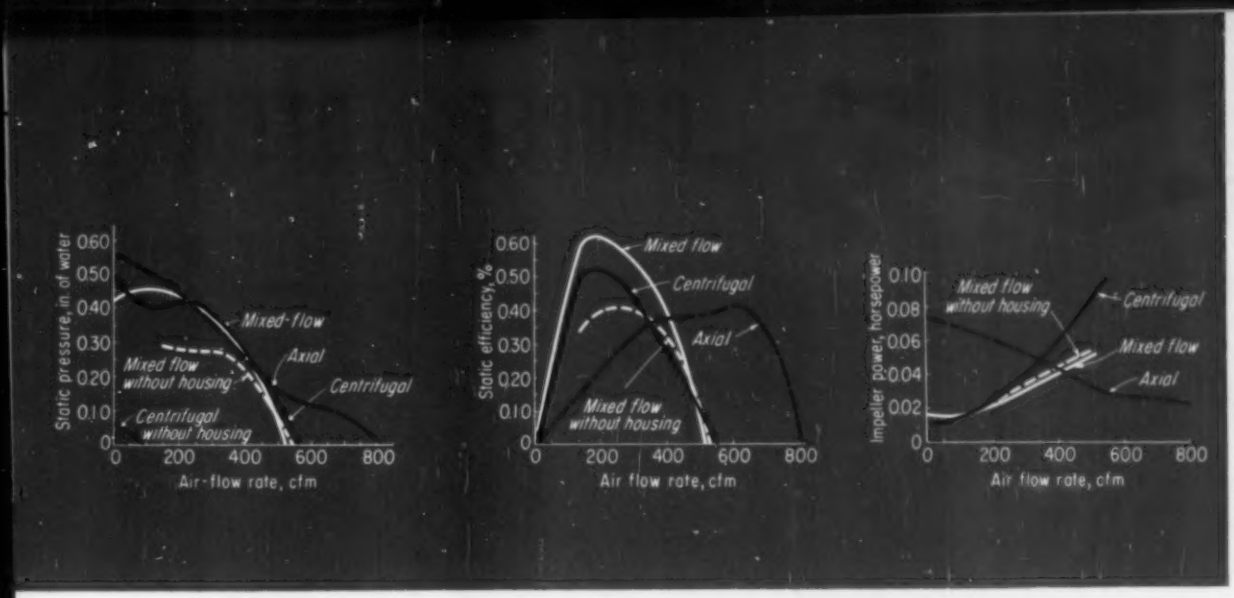
Getting Nearer the Efficiency Peak

As none of these impellers is operating at maximum efficiency in the appliance range, the possibility of decreasing the specific speed of a given air-flow system to a value corresponding to peak static efficiency for an impeller is certainly worth considering. For example, assume that the specific speed of a particular flow system can be reduced from 55,000 rpm to 25,000 rpm by decreasing flow-path area and thereby increasing system resistance. This change would mean that both centrifugal and mixed-flow impellers would then operate at or near peak static efficiency.

However, system resistance should be increased only if the gain in reducing the size of the air conditioner more than compensates for higher noise and power consumption that may result. So far this has not been possible because impeller speed or size usually must be increased to raise the air-flow rate again by the amount lost when the system resistance was increased.

How Housing Affects Performance

The mixed-flow impeller is normally installed in a housing very similar to standard housings recommended for conventional centrifugals. The scroll shape in a centrifugal-fan housing is designed to convert the velocity pressure at the wheel periphery to static pressure at the housing discharge. Because most of the pressure conversion in a mixed-flow impeller takes place within blade passages, its performance is far less dependent on the specific housing configuration. This can be noted from the pressure-flow curve comparing centrifugal and mixed-flow impellers with and without housings, Fig. 4. The centrifugal impeller cannot be used without a housing—in fact, care must be taken even when altering or redesigning the shape of its housing.



Mixed-flow impellers should have a housing whenever possible even though pressure losses without housing are not excessive. Not only is additional static pressure useful, but the housing collects the air discharge for distribution in the flow system. It is possible to eliminate much of the mixed-flow housing so as to save valuable space in both width and height while sacrificing little in performance. In the case of such a partial housing, the mixed-flow performance curve will lie somewhere between the housing and housingless curves.

Relative Pressure, Power, Efficiency

Actual test results on three impeller types with and without housings are shown in the three curves of Fig. 4. The curves were obtained under ideal conditions and therefore are not representative of operation in actual air-conditioning units. For a fair comparison, impellers were selected so that the pressure curves virtually overlap in the range of operating points most common in room air conditioners. All three curves nearly intersect at two operating points: $p_s = 0.415$ in; $Q = 225$ cfm; and $p_s = 0.20$ in., $Q = 440$ cfm—all at a motor speed of 1,000 rpm.

The curves show that in the operating range between 225 and 440 cfm, the mixed-flow is more efficient than the centrifugal because less power is needed to produce the same pressure output. On the other hand, the axial impeller operates most efficiently at high flow rates and low pressures. This characteristic of axials is also evidenced in the dropping power curve. Conversely, the centrifugal and mixed-flow impellers both have rising power characteristics.

Air-conditioning Requirements

Space and styling requirements also effect actual operating efficiency of an impeller. Although it is possible to build air-moving units specifically matched to each impeller type so that the impeller will operate at its maximum efficiency, the design is usually governed by customer requirements. For example, room air conditioners must project as little as possible into a room—and the allowable projection is shrinking each year.

The problem is twofold: To provide ample flow area on the intake side of a propeller fan for max efficiency, a window air-conditioning unit would project too far into the room and require two motors. Also, an efficient centrifugal fan would be wide (high width-to-diameter ratio) and therefore would also require that the window unit project far into the room. To reduce the unit width in each case, radical changes in configuration would be necessary which unavoidably reduce the operating efficiency of the impeller. The space configuration of the mixed-flow impeller, on the other hand, permits a much shorter projection into the room even when the air-conditioning unit is designed to allow max impeller efficiency.

Two mixed-flow impellers, for example, were recently installed in a ¾-hp room air conditioner. The fans, 10 in. and 9 in. dia, replaced a 11-in. propeller fan on the condenser side and a 9-in. propeller fan on the evaporator side. Tests under identical conditions before and after the changeover showed:

- Fan motor load reduced from ⅓ hp to 1/25 hp—about 60%. A 4-pole shaded motor at 1570 rpm was replaced by a 6-pole shaded motor at about 1000 rpm.
- Over-all noise level was reduced 10 db on the evaporator side and 6 db on the condenser side.

Although the total impeller power is only a fraction of the power required by the compressor, reduction in impeller power will allow the manufacturer to increase his rated output. Because of restrictions on total unit current, even a saving of a fraction of an ampere on motor current can be a vital design objective. And, of course, a lower noise level is one of the strongest product features in marketing room air conditioners.

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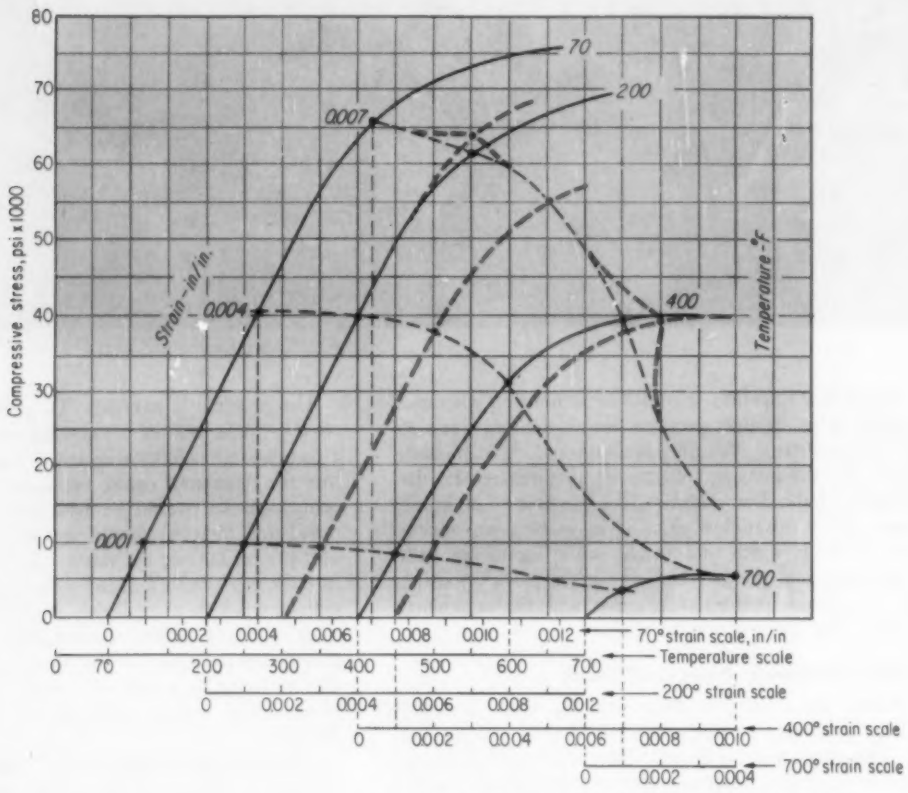
READING IMPROVEMENT

This article is the example used in the first of our series of reading-improvement lessons, appearing on page 29 in this issue. (Answers to the comprehension questions are: *lower; conical; static pressure; small; axial.*) The second lesson will appear next week; watch for it.

CARPET PLOTTING



1 First step . . .

to a useful carpet pilot of high-temperature, short-time compression properties is to space out the stress-strain curves in proportion to their respective temperatures. To do this, lay down a convenient temperature scale, as shown, for reference purposes. Origin of the 70-F curve, then, is opposite 70° on this scale. With this stress-strain curve plotted, stagger the same strain scale so its origin coincides with the next temperature, here 200°, for which data is available—and plot this curve. Scales are usually staggered in a direction that will open the family of curves rather than close it. Here, staggering is to the right until all curves (here, only four—in solid black) are plotted.

Now, cross-plotting is easy and automatic. For example, take a constant strain of 0.001 in./in. Using the correct strain scale for each curve, mark the point on each curve that represents 0.001 in./in. By connecting these points (lowest heavy black dashed line), the data is converted to stress vs temperature—for a constant strain level. Two other cross-plots are shown here: at 0.004 and 0.007 in./in. This criss-cross of constant-temperature stress-strain curves with constant-strain stress-temperature curves forms the carpet.

Self-checking nature of carpet plotting is shown by the two colored dimples shown on the 0.007-in./in. cross-curve. Take the one near the 200° stress-strain curve

Assume that the materials lab read the stress values too high during the 200° test, as shown by the colored dashed line. When the 0.007-in./in. strain cross-curve is plotted, the point for 200 F forces the curve to deviate locally from its smooth contour—indicating the possibility of a data error. Similarly, if data for 400° were recorded for 450° data by mistake, the curve is plotted 50° too far to the right, as shown in color. Using the new (but incorrect) origin, the 0.007 point will also be too far right, and the constant-strain cross-curve would have to bulge suddenly to encompass it—again indicating possible error. Not all bulges are errors: near transition points, for example, the whole carpet may show local irregularities.

Interpolation is simple too. Here, the constant-strain cross-curves are used to construct a stress-strain curve for a temperature at which test data are not available. Since the curves are spaced along the abscissa proportionately to their temperatures, the stress for any strain at an intermediate temperature can be found by following along this constant strain until a horizontal distance has been traversed proportionately to the new temperature. With a 300° curve, for example, horizontal distance between points of constant strain on the 200° and 400° curves is 4 squares. Thus, moving horizontally 2 squares to the right from the 200° stress-strain curve, and dropping vertically to the same constant-strain cross-curve, gives a single point on the desired 300° curve. Other points follow as shown.

— new way to display

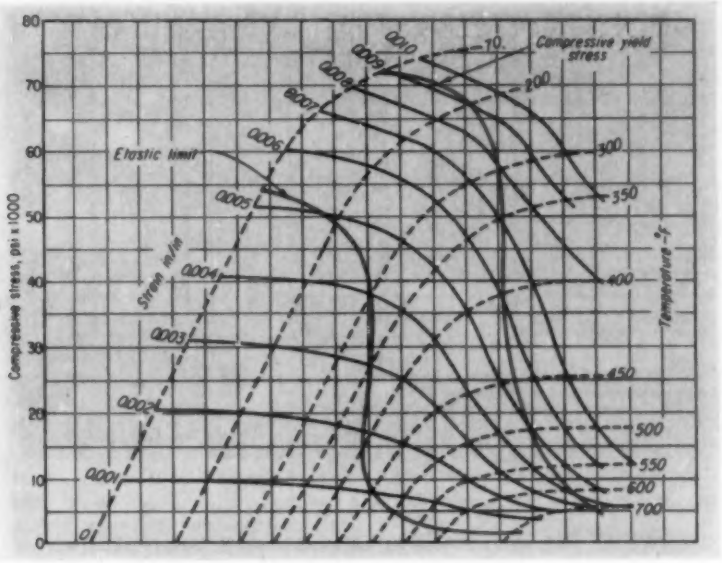
HIGH-TEMPERATURE MATERIALS DATA

OLD WAY needs two sets of curves to show interaction of three variables—stress, strain, and temperature. NEW WAY speeds the design job by plotting everything on one sheet, giving these advantages:

- **Eliminates cross-plots for intermediate values**
- **Makes boundary conditions easy to see**
- **Shows up data errors during plotting**
- **Simplifies interpretation for conditions not covered by data**

In a previous article (*PE*—June 3, '58, p 135) the author explained the rudiments of carpet plotting. In the present article he applies them to the short-time high-temperature compression properties of 7075-T6 aluminum. Here's step-by-step procedure showing how to carry this latest technique for presenting elevated-temperature data right through to handy design charts.

ALEXANDER KRIVETSKY,
Head, Internal Structures Research
Space Flight & Missiles Div
Bell Aircraft Corp, Buffalo



2 The resulting carpet . . .

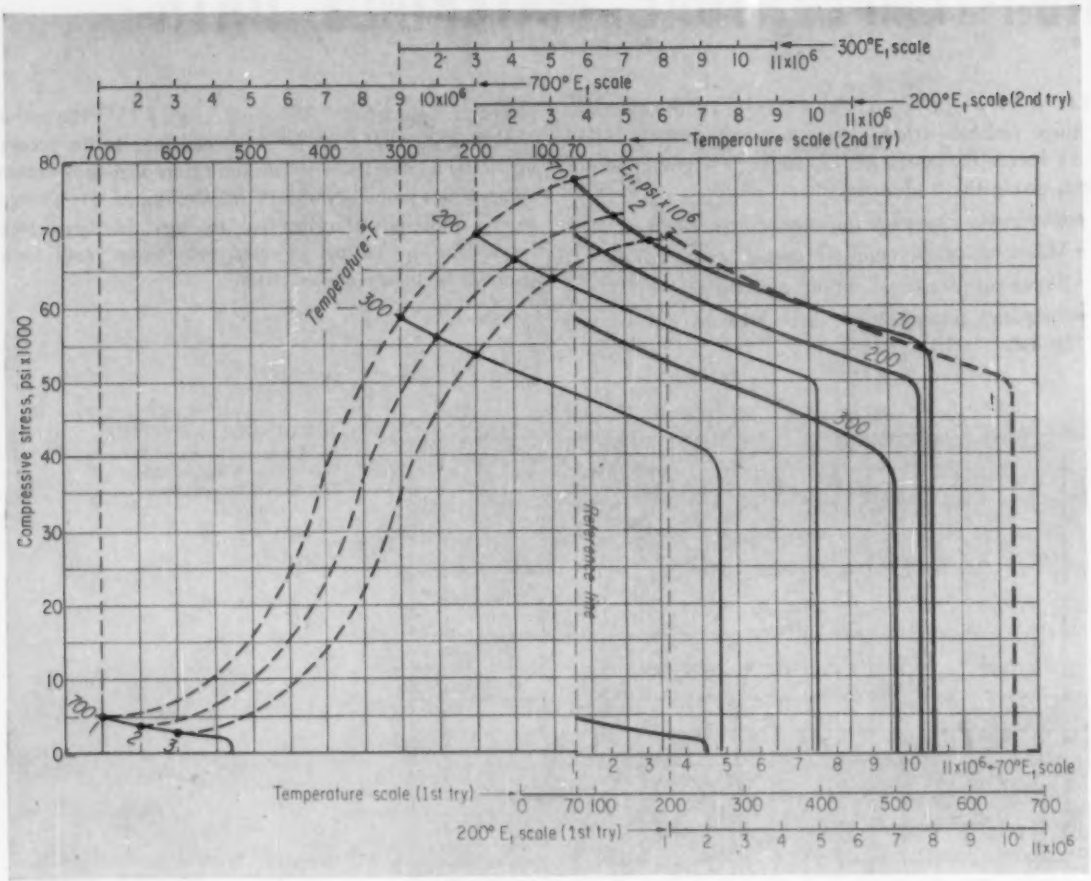
of compressive stress-strain curves vs temperature contains many more temperature curves and constant strain cross-curves for easy design use. Since staggered strain scales were used, a single strain scale cannot be shown along the abscissa; however, the strain for any stress level can be read off the desired temperature curve by using the constant-strain curves. For example, take 50,000 psi at 300 F: This point lies 6/10 of the horizontal distance between the 0.005 and 0.006 strain-curve intersections with the 300° stress curve. This gives a value of 0.006 in./in. for the desired strain.

Boundary conditions are easily displayed on carpet plots. Two are shown here in color. Left-hand curve connects the elastic limits of all the curves, thus is the boundary between the elastic and inelastic domains. The right-hand colored curve passes through the yield point for each curve (0.2% offset yield), establishing a clear picture of a boundary commonly used in structural design. The sharp influence of temperature on these two design limits is readily apparent.

Stress-strain curves for odd temperatures can be quickly spotted in by the designer following interpolation procedure described in the previous illustration. On the finished carpet shown here, the 250-F stress- strain curve has been purposely omitted. Take a pencil and test your understanding of how the carpet works by spotting in the 250° curve yourself.

This basic carpet plot of properties is just a starting point for the designer, for many more useful design curves can be constructed from it. For example, the initial slope for each curve can be quickly picked off and a plot then made showing how elastic modulus varies with temperature. The yield-stress curve can be lifted and replotted vs temperature; in fact, if a series of basic carpets are made for exposure times other than the ½ hr used here, a carpet can be made of yield stress, temperature and time. *(Cont'd, next page)*

CARPET PLOTTING



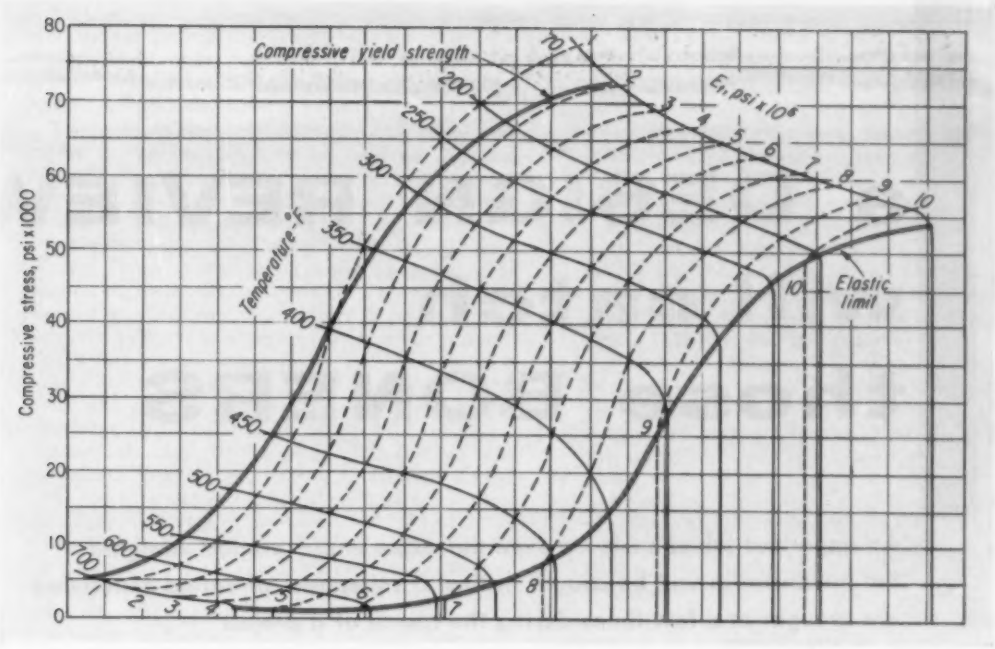
3 Tangent modulus . . .

appears in design wherever inelastic action is a factor—in simple Euler columns and aircraft fuselage panels, for example. By definition, the tangent modulus E_t is the slope of stress vs strain at the stress level in question. This makes it a cumbersome quantity to use in design, so a carpet plot of E_t is a logical next step from the basic plot of Fig. 2.

The colored stress-E_t curves above result from picking off E_t at a series of stress levels from each of the basic stress-strain curves in Fig. 2. This is the normal way tangent modulus is plotted, except that E_t is usually taken as the ordinate. Purpose of the reversal is to make subsequent scale staggering horizontal instead of vertical. Colored scales show the first attempt at staggering, purposely executed incorrectly to show trouble spots. Because these curves have no common origin, the common value of $E_t = 1x10^6$ psi is selected as a starting line. A trial temperature scale is drawn moving to the right, with 70° coinciding with $E_t = 1x10^6$ on the 70-F curve. Staggering the first scale to the right, for the 200° curve, the error becomes evident: The curves will overlap and be hard to read.

Second try gives a better result. By running the temperature scale to the left, starting from the same reference lines, the family of curves opens up—simplifying construction. With the 70° curve in place as an anchor (located so the 0° end of the temperature scale coincides with a major grid line, making subsequent plotting easier), the 200° curve is re-plotted using an E_t scale staggered left so its origin ($E_t = 1x10^6$) coincides with the 200° mark. Likewise, the 300° and 700° E_t curves have been replotted on the staggered scales shown at the top. Only four curves, in solid black, are shown here for the sake of simplicity.

Now, constant E_t cross-curves can be drawn by connecting the points on each curve that represent the same value of E_t. First such cross-curve is $E_t = 1x10^6$, the dashed curve farthest to the left. Next comes $E_t = 2x10^6$, and so on. Each point of intersection on an E_t curve is found, using that curve's staggered scale. However, the various scales need not be drawn in. With the $E_t = 1x10^6$ points known, other points are easily found by using the common scale marked on a piece of paper.



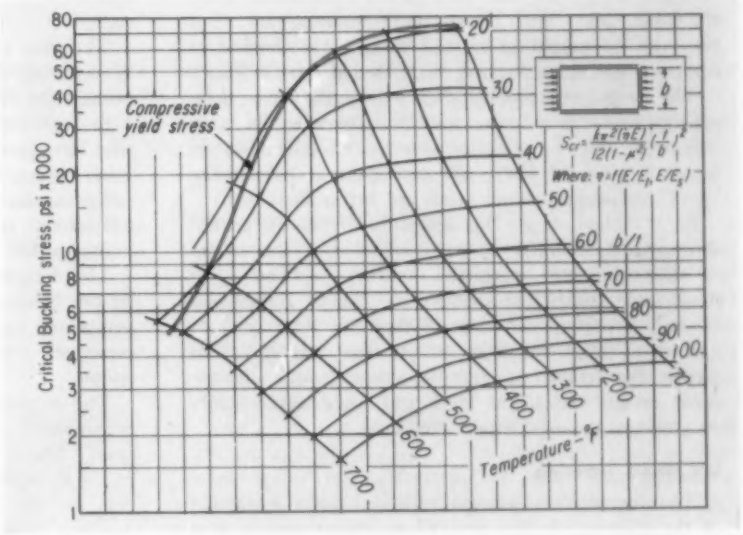
4 Finished carpet . . .

for tangent modulus, stress and temperature looks bare when construction scales are not shown, but is ready to use. Colored boundaries are yield strength and elastic limit. Yield boundary moves outside the carpet simply because above about 400 F the yield strength for this alloy is greater in this area than the stress corresponding to $E_t = 1 \times 10^6$. Constant E_t cross-curves become vertical below the elastic limit boundary because in the elastic domain $E_t = E$, and stress has no effect. A carpet very similar to this can easily be constructed from the basic stress-strain carpet, Fig. 2, for the secant modulus—a parameter almost as common to buckling problems as tangent modulus.

5 Buckling stresses . . .

in carpet form for a simply supported plate shows the ultimate refinement of high-temperature materials data for the designer. Buckling stresses depend upon geometry and, as shown by equations at right, on material properties like elastic modulus E, tangent modulus E_t and secant modulus E_s.

But solving the buckling equations is an arduous cut-and-try method, since stress is on both sides—on the left s buckling stress, on the right as stress-dependent efficiency factor η. The carpet plot, right, represents this equation for many temperature levels, and is built upon the other material carpet plots discussed in this article. Although the initial labor is great, time spent to reach a final design carpet like this is worthwhile because of the clear picture given of a complex buckling situation. For example: a panel 0.1 in. thick at 70° will support stresses in the order o. 10,000 psi without buckling if stiffened every 6.2 in.



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a DESIGN REVIEW will catch those BONERS

An important job can trip up even the experienced product designer. But his mistakes will be caught in time if colleagues of varied experience are brought in a few times during the course of a project to quiz him on how it is shaping up.

D P SIMONTON
RCA Missile & Surface Radar Dept

The designer thinks he is doing fine as he plans new equipment. What he doesn't realize is that he is calling for specially machined gears where standard off-the-shelf items would do just as well . . . or that he is specifying indicator lamps that can't be replaced without taking off the front panel. Such boners aren't anything new. But they can be caught in time if designs are checked at certain stages along the way by a Design Review Panel.

The entire engineering staff will profit from these get-togethers—the old-timer and the newcomer; the inexperienced, and the seasoned veteran. Such reviews are based on a pair of pretty safe assumptions; anybody can "goof" in design; several heads are better than one.

So at certain stages, the design undergoes the critical scrutiny of a committee of senior engineers. The makeup of the committee recognizes another principle—older heads know things that younger ones don't. This is particularly important nowadays. Systems are more complex and experienced engineers are in short supply. This pushes the seniors up into coordination and management groups and places more and more responsibility on younger, less-experienced shoulders.

It's Good Training

Training of these younger men is a major byproduct of the reviews. In the press of an urgent project, it is often impossible to seek out senior men who have had previous experience with a particular design problem. Design reviews bring such individuals together as a matter of course—not only to solve known problems but to unearth others. Newly hired engineers get acquainted with "the oracle" in each specialized field and when new problems arise, they can go straight to him. This kind of horizontal communication is very effective in reducing delay. It also avoids the destructive ill feeling that results from "going over the head" of responsible designers.

The very existence of the program makes itself felt in everyday decisions of the young designer. When pressed for delivery it is all too easy to say, "I'll push it through half-designed . . . and fix it up later." Those who have been through a job or two realize that "later" never comes; the first guess actually goes into the field —if it can be made to work at all. Knowing the design will have to run a ganlet provides a sort of subconscious design-quality control.

The designer may go into his first review so nervous he can barely hold a pencil, but after a few sessions his composure and self-assurance return. He develops "stage presence," a quality traditionally lacking among technical people.

The engineer whose design is being reviewed must be prepared to answer questions and justify design decisions. There is no better way to analyze a design than trying to explain it to somebody else. Even the preparation for the review often uncovers mistakes. It also develops thoroughness—a must for all engineers, but particularly important for good product designers.

Who Participates

A mechanical-design-review committee should consist of the following people:

10 Areas Where Review Pays Off

Here are the kinds of challenges and questions that a review committee may throw at the design engineer.

• **Reliability.** Have environmental tests been conducted to prove reliable operation in shock, vibration, humidity, salt spray? Has the selection of parts included only those whose lives have been proven (or are being proven) through adequate testing?

• **Maintainability.** The customer spends about 10 times as much money to maintain electronic equipment as he does on the initial purchase price—let's not make it any worse. Can burned-out indicator lamps be replaced readily from the front, or must the whole panel be removed? Can a man get his fingers around each tube shield or will he need a special tool? . . . will he burn his fingers? More basic, just what is the maintenance philosophy of the equipment? Will maintenance be by unit replacement, or trouble-shooting? Will chassis be in the cabinet or on the bench? In a shop or in the field? It makes a difference. Does the assembly under review meet requirements for minimum downtime?

• **Adherence to specifications.** Are insulating materials fungus-proof? Does the equipment have to operate in an explosive environment? If so, get rid of open relays or other arc-producing parts. Is the finish the right color?

• **Value Engineering.** When specs don't make sense, they should be questioned. Does indoor equipment really have to operate at –65 C? Does stationary gear really have to withstand 50-g shock? Should you pay $20 apiece for stainless-steel jigs that straighten tube pins, when you can buy diecastings off the shelf for $1.25?

• **Standardization.** Don't do unnecessary design work. Use beefed-up sections when weight is not a major consideration, and forget about special high-strength alloys. Why machine special cluster gears when standard ones are available off the shelf? Is the grounding problem really critical enough to require a silver-plated chassis? Why use a special blower? The same one throughout may mean throwing away a few cfm, but this will be a lot cheaper than preparing an extra drawing, finding a new vendor and testing, stocking, processing an extra part. There may be several "right" ways to accomplish a design goal, but there is only one standard way—use it.

• **Reproducibility.** Possibly the modelmaker was able to trick an assembly together and make it work, but can the man in the production shop do it economically or at all? Does the design depend on a part made by a single-source vendor? If an undimensioned radius is changed by the vendor, will parts still fit together?

• **Safety.** Are areas surrounding knobs and access doors free of "knuckle nibblers"? Are test points well removed from dangerous voltages and hot spots? Are high-voltage controls well insulated from their shafts? Does the operator risk getting his fingers into a power gear mesh or a fan blade?

• **Finishing.** Does the paint finish include an adequate primer? Will electrolysis result from intimate contact of dissimilar metals? Will weldlaps permit ready draining of finishing reagents, or will there be entrapment and corrosion?

• **Human Engineering.** To work really well, machines have to fit people. Are controls logically arranged and labeled? Does the operator have to lie on his belly to read a meter? Will room lights glare into his eyes when he's seated at the console? Will he bark his shins on a brace across the back of the knee hole in a console? Can he reach controls without stretching, or removing his attention from indicators?

• **Drafting.** Are notes complete and comprehendible? Is proper part-marking called for? Do dimension groupings and datum lines make sense? Are tolerances reasonable? Do backlash limits on gear trains specify which shaft is locked and which is deflected.

Chairman who coordinates the meeting and writes the report. He is usually not a member of management —if so, he is certainly not in the higher echelons.

Mechanical-design engineer whose design is being reviewed. He comes equipped with calculations, sketches, layouts, drawings and (if possible) a laboratory model. Unless design is straightforward, sketches or drawings should be distributed to each member of the committee before the meeting.

Lead mechanical engineer who is responsible for the subsystem or major unit of which the particular design is a part.

Mechanical engineering supervisor.

Senior mechanical engineer who has experience in the type of design under review. He acts as a consultant, preferably with no direct responsibility for the design. He usually has a reputation for a "gimlet eye and a long nose" and may well be the most important member of the committee.

Project engineer who answers specialized questions on other phases of the system and keeps himself abreast of design progress.

Drafting supervisor who assures good drafting practice is followed. He may not be present if finalized drawings are not a part of material being reviewed.

Additional consultants who are invited from Methods Engineering, Human Engineering, Reliability, Field Service, when their particular interests are at stake.

But there are problems

By nature a design engineer is an individualist who likes to inject his own personality into his work—the things he designs. This is particularly true of the younger men, some of whom still display traces of the independence and secretiveness required of them in school—but a hindrance to a good design team. Setting these beginners straight is not a matter of, "OK, junior, bring in your little treasure so your elders and betters can tear it apart." No one would think of conducting a design review on that basis. The diplomatic approach is better. Here the senior man says candidly, "I tried that once, and here's what happened. . . ."

Creativity could be stifled if raw authority were used to push design changes through—or to veto what the reviewer happens merely to be prejudiced against. The equipment would suffer because the state of the art would stagnate. And a damper would be put on the

Scheduling the Design Reviews

At RCA, design reviews are specified for both the electrical and the mechanical aspects of a newly designed equipment. Electrical design reviews come first. Here such things as circuitry, electrical part selection, reliability and critical circuit configurations are established.

When these specifications are set, detail mechanical design begins. The schedule calls for regular mechanical design reviews. However, if work is incomplete, reviews can be postponed until they can become meaningful. Or if a number of similar assemblies are used in the system, a complete program of reviews is probably not necessary; details can be thrashed out on a "guinea pig" while all similar mechanisms get only a routine pre-release review.

Type of review depends upon design status. In general, reviews are of four different types:

- Concept review, as soon as mechanical layout is sufficiently complete to indicate adequacy of general design features. It determines whether or not the designer is headed in the right direction before committing too much in the way of time and material.
- Pre-release review after drawings are complete enough to make a detailed check on the design, but before drawings for developmental model are released to the model shop. This review knocks out excess cost by taking a fresh look at the application of parts, materials, finishes and processes.
- Large-quantity release review (if such quantities are indicated) considers reproducibility of that particular quantity (weldments vs sand castings vs forgings). Purchased parts also get a careful screening for standards, procurability and status of reliability testing.
- Miscellaneous or electromechanical review may be held during any phase of the project. Combined electrical-mechanical reviews might cover such areas as high voltage circuits, timing mechanisms, servo systems, and assemblies presenting special heat, shielding or environmental problems.

designer's creative imagination. But when suggestions for improvements are made with tact and supported by logical reasoning, such reviews can catalyze better design. And the designer is reassured that changes are reasonable, not just a whim, pressured through by a senior engineer.

Gloves or Fist?

Recriminations are not allowed at the review table. As soon as participants start playing the old game of "Who struck John?" the program has lost its usefulness. The theme is, "Is this a good design?" and if not, "What should be done to fix it? Who should do it?" Never mind who made the error. The thing under review is the design, not the designer.

Teeth are nevertheless required. Without strong, decisive leadership, engineers may let their duties slide and, as a result, the whole program will suffer. If a committee chairman writes a report containing the most masterful recommendations for saving a bad design from almost certain failure–and then allows that report to get lost in the file–he has wasted his own time and the time of the committee. Management must stand squarely behind the program and see that action results from the review–not necessarily 100% incorporation of the committee's recommendations, but at least some effective correction of recognized faults or justification for leaving the design alone. Faults that are discovered are usually not just mere peccadillos–some have been so knotty that outside consultants had to be hired just to solve them.

Concentrated effort is necessary to get the review program off the ground. Behind a successful program are one or two missionaries who keep pushing and advertising. Once established, however, it tends to be self-sustaining. It fits comfortably into the scheme of things–so much so that designers want reviews. But they must be scheduled early enough in a project so recommended changes are incorporated without upsetting drafting schedules, and certainly without having to rework jigs, tools or, in the extreme case, completed hardware.

Sales Psychology

Selling the program is probably not so much a matter of organization as it is personality. A good salesman, almost anywhere in the engineering organization, could be responsible for pushing the thing through. But it is probably easier if the design review chairman is given responsibility, deriving his authority directly from management. This way, management acts mostly as an advisor to the local chairman, who deals directly with his everyday associates. It seems less like outside interference–at least initially.

Final payoff of a successful review program is improved equipment and a more experienced engineering team. The equipment requires a minimum of debugging, rework and engineering changes; it is compatible and easily maintained. The design team learns and matures through the shared experience of each man, and is better able to benefit as a team from the particular specialties found in its members.

EDITOR'S NOTE: Besides debugging a product, committee analysis can concentrate on designing it for lowest cost. "Catalyst for a Better Product," Dec 2 '57, p 30, describes how General Electric calls together representatives from Engineering, Purchasing and Manufacturing for a Value-analysis Seminar—saving thousands of dollars yearly.

"Product Development Conference," Oct '55, p 129, describes another kind of get-together for improved product design. Stenographic excerpts from a three-hour-long conference allow you to sit in with product engineers at Yale & Towne while they discuss appearance, communications and product changes for a new line of industrial trucks.

Product planning is another area where committees have proved valuable. "Product Development—a Running Start," Sept '55, p 179, tells how a committee chooses new products, controls accumulation of data, determines performance specifications, estimates sales volume and selling price—every step of the cycle in evaluating a new product.

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SINGLE-PLATE GEAR TRAINS:

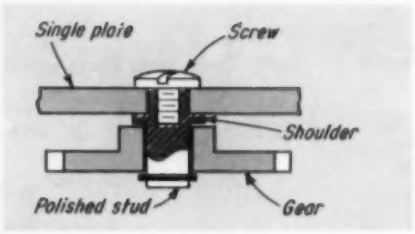
11 ways to

Precision gear trains mounted on single plates are easier to assemble and inspect than the more conventional double-plate mounts. Practical plate-thicknesses and commercially available bearings, however, are too thin to provide adequate bearing support for the gear shaft.

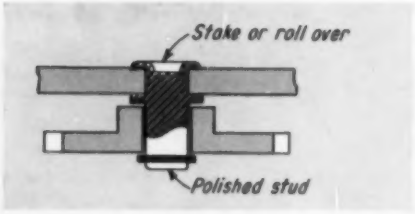
Gear mounts illustrated here solve the problem. Some typical design restrictions are:

1. Precision
2. Space available on gear plate
3. Gearing load (torsional or axial)

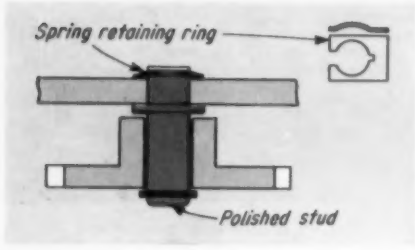
But one or another of the following arrangements will usually satisfy any combination of requirements.



1 Screw-held

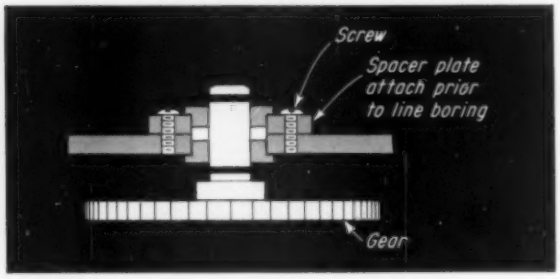


2 Riveted



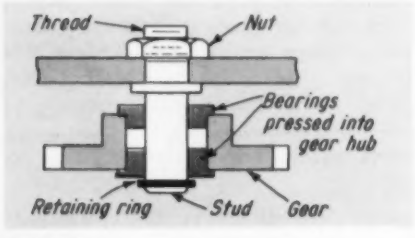
3 Retaining ring

Polished studs . . .
may be held in several ways. The gear-hub length is sufficient to provide, with the polished stud-surface, adequate bearing support



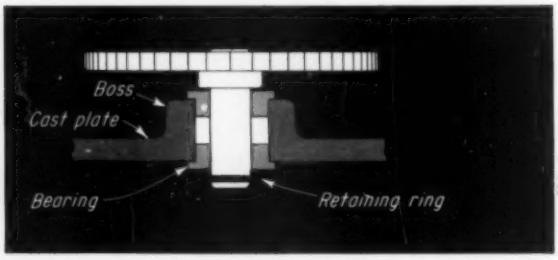
5

Spacer plate . . .
attached before boring hole for the bearing allows mounting two ball bearings in line on virtually a single plate.



4

Two ball bearings . . .
pressed into gear hub give more precision than plain journal-bearing type of stud mount in previous examples.

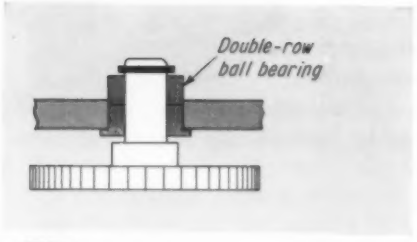


6

Boss in cast plate . . .
performs same function as spacer plate, but eliminates much assembly. Also, bearing misalignment is virtually impossible.

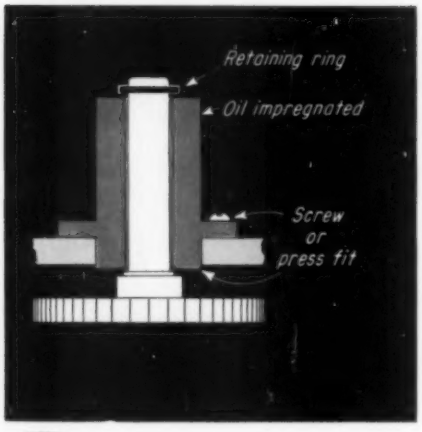
MOUNT SHAFTS

FRANK WILLIAM WOOD JR. *Design Engineer*
Vitro Laboratories, Silver Spring, Md



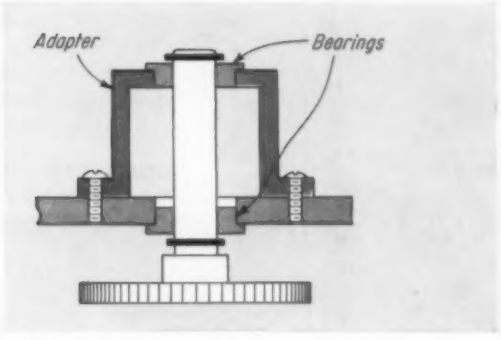
7

Double-row . . .
ball-bearing unit in single plate has enough bearing length but is more expensive than two single-row bearings.



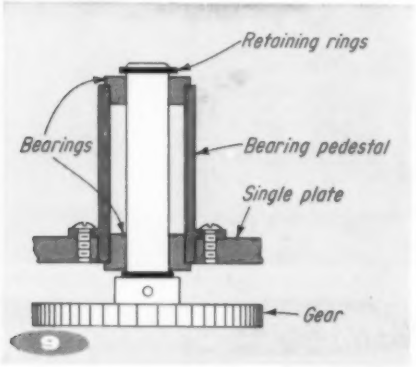
8

Oil-impregnated . . .
bearing of sintered material provides self-lubricating pedestal that supports shaft and functions as bearing.



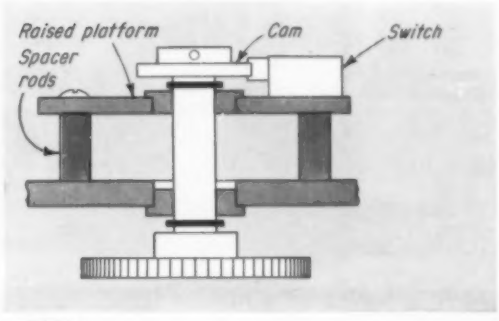
10

Adapter assembly . . .
must be located accurately unless mounting holes for the bearings are made after adapter has been fastened to the mounting plate.



9

Bearing pedestal . . .
of flanged tube obviates bearing-alignment difficulty, can be assembled separately as a unit.



11

Raised platform . . .
accommodates switch or other component as well as bearing. Gear shaft is also accessible during operation.

1649 TIMERS

that **SOLVED** special control problems.

• How this engineering experience can help you.

The small Time Delay Timer represents one of the simplest motor driven timers we manufacture. It is a reliable standard fixed time delay type.

Industrial Timer also manufactures this Punched Tape Programmer which controls 85 individual load circuits through an unlimited number of steps. No coding or elaborate memory systems are required, making possible direct control from Programmer to process.

Between these two extremes we list 1688 different timers, of which 39 are standard types and 1649 are "specials" developed to solve difficult control problems.

Most timing problems have their own unique characteristics. However, it very often happens that a control problem is quickly solved by one of these 1649 already developed special timers. If not, we have the staff, the experience (20 years) and what's more important, the desire to design and deliver the timer that fills your needs 100%. Send us your specifications.

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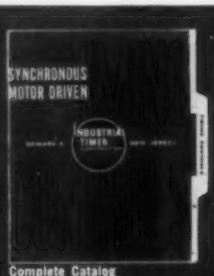
Ask for complete catalog or individual bulletins by number



Complete Catalog Timing Controls

No. 100 Card & Tape Programmers

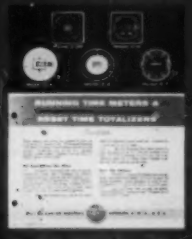
No. 200 Motor Driven Cam Timers

No. 201 Multi-Cam Timer Kit

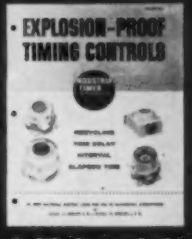
No. 300 Motor Driven Time Delay Timers

No. 400 Motor Driven Interval Timers

No. 500 Motor Driven Recycling Timers



No. 700 Time Meters & Time Totalizers



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Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

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AFFILIATE—LINE ELECTRIC COMPANY

how much force to DEFLECT a SPRING SIDEWAYS?

Formulas for force and stress when a side load deflects a vertically loaded spring.

W H SPARING, *Mechanical Engineer*
American Steel Foundries, Chicago

There are many designs in which one end of a helical spring must be moved laterally relative to the other end. How much force will be required to do this? What deflection will the force cause? What stress will result from combined lateral and vertical loads? Here are formulas that find the answers.

It is assumed that the spring ends are held parallel by a vertical force P (which does not appear in these formulas), and that the spring is long enough to allow overlooking the effect of closed end-turns.

Lateral load for a steel spring

$$Q = \frac{10^6 d^4\ \delta_L}{AnD\ [0.204\ (L-d)^2 + 0.265\ D^2]}$$

where n = number of turns = $(h/d) - 1.2$, D = mean dia in., A = correction factor.

Lateral deflection

$$\delta_L = \frac{AQnD\ [0.204\ (L-d)^2 + 0.265\ D^2]}{10^6 d^4}$$

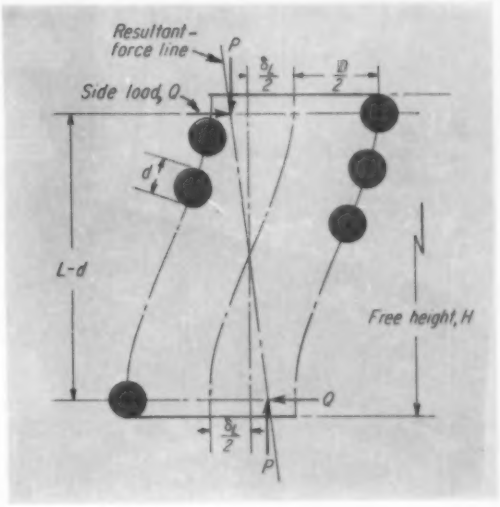
The correction factor A can never be unity (see chart on continuing page); also P can never be zero.

This is because there will always be some vertical deflection, and a side load will always cause a resultant vertical force if the ends are held parallel and at right angles to the original center line.

Combined stress

$$f_c = f\left\{1 + \frac{1}{D}\left[\delta_L + \frac{Q}{P}\ (L-d)\right]\right\}$$

where f = vertical-load stress. Accurate within 10%, these formulas show that the nearer a spring approaches its solid position, the greater the discrepancy between calculated and actual load. This results from premature closing of the end-turns. It is best to provide stops to prevent the spring from being compressed solid. An example shows the combined stress at the stop position may even be higher than the solid stress caused by vertical load only.



A Working Example

A spring has the following dimensions, in inches:

Outside dia	9
Bar dia (d)	1 15/16
Free height (H)	16 1/2
Solid height (h)	13
Loaded height (L)	14 5/16
Lateral deflection (δ_L)	1 1/2
Stop height	13 3/4

From these dimensions compute values at loaded height and stop height.

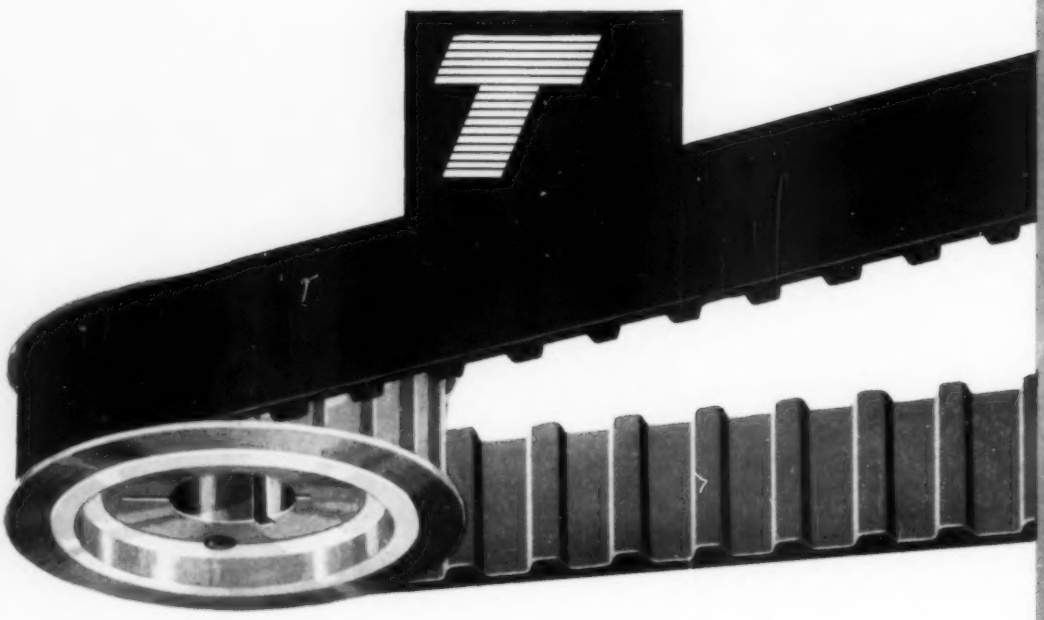
	Loaded position	Stop position
D	7.0625	7.0625
n	5.51	5.51
y (vertical deflection)	2.1875	2.75
$H - d$	14.563	14.563
$L - d$	12.375	11.813
$(H - d)/D$	2.06	2.06
$y/(H - d)$	0.150	0.189
A	1.30	1.40
Q	9400 lb	9310 lb

From standard formulas for vertical loads only:

Solid load	36,300 lb
Load at stop	28,500 lb
Stress f when solid	141,500 psi
Stress f at stop	111,200 psi

(Continued on page 73)

US PowerGrip



for No-Slip Drives

The U. S. PowerGrip "Timing"® Belt, a "U. S." invention, has been one of the true sensations in power transmission since it was patented eight years ago. Thousands of plants have converted drives to this more practical means of transmission. Its use has greatly increased the efficiency of industrial machinery and given rise to new appliances and original equipment by the score.

The "'Timing' Belt with Teeth" is known throughout industry as the "T" belt, a term as significant as the "V".

The U. S. PowerGrip "Timing" Belt gives positive, non-slip performance and requires no maintenance, no lubrication. And because this belt requires no appreciable tension at installation, it thereby prolongs bearing life. Your U. S. PowerGrip Transmission Distributor carries all stock sizes and can give you the benefit of his long experience in converting to the modern T.

• • •

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

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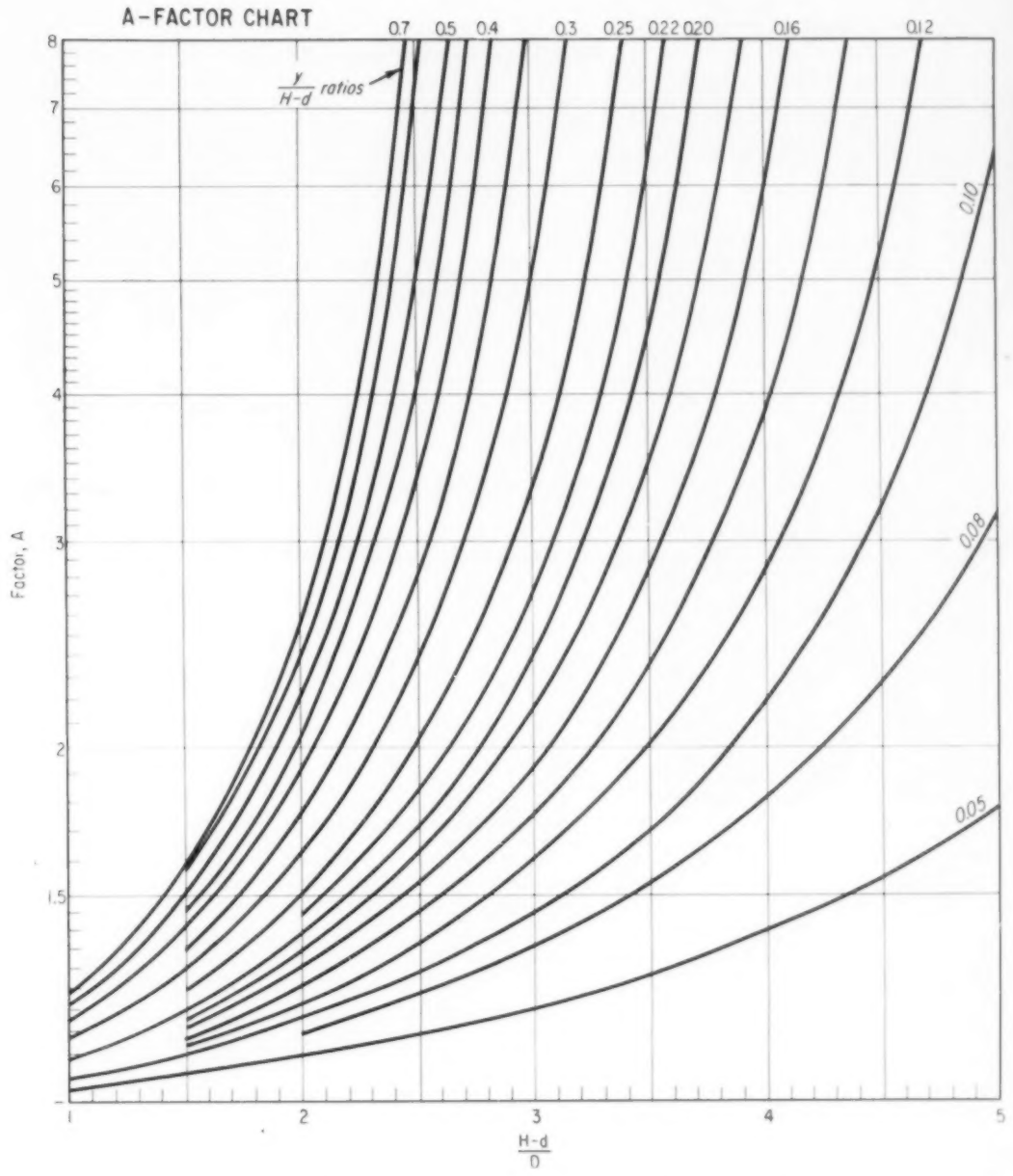
Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

how much force to DEFLECT a SPRING SIDEWAYS? (cont.)



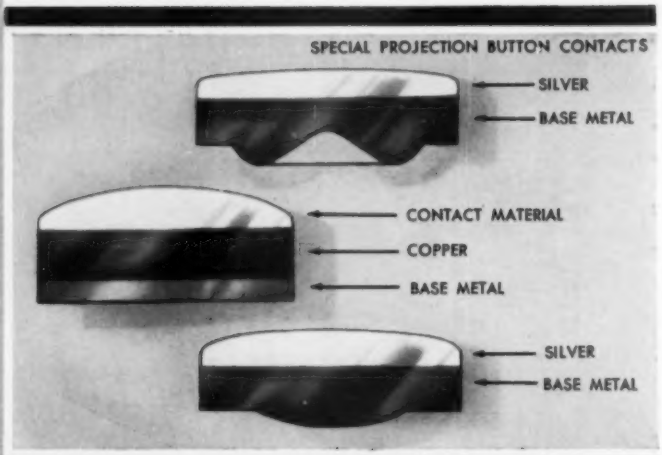
From the combined-stress formula

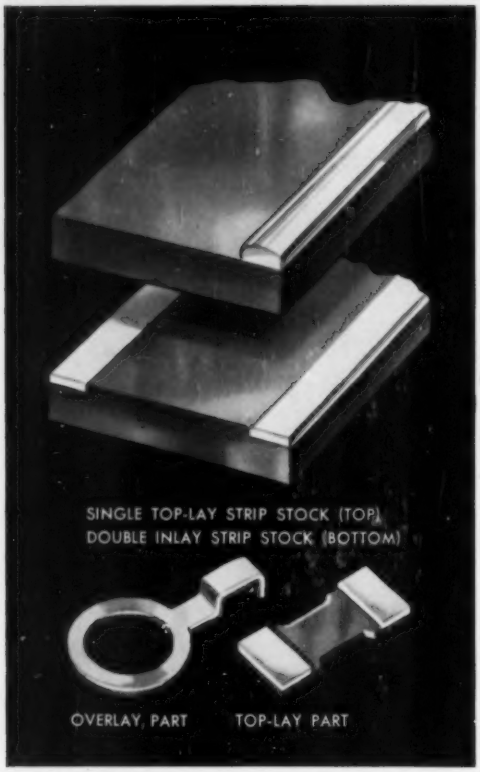
$$f_c = 111{,}200 \times 1.759$$
$$= 195{,}600 \text{ psi}$$

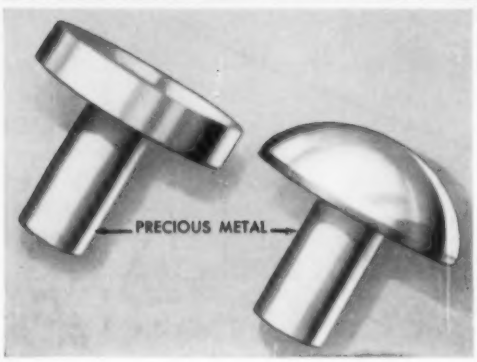
This stress is so high that setting in service would occur. This particular spring should be redesigned. Generally, combined stress under the worst condition anticipated should not exceed the solid stress caused by vertical load only. A stop at a reasonable height above solid height is thus desirable—otherwise, spring may have to be modified.

GENERAL PLATE

Anticipates Tomorrow's Contact Problems Today







In today's rapidly changing industrial activity, product design and performance standards often become obsolete quickly. General Plate engineers understand this situation and are constantly working to develop new ideas in contacts and contact materials to be ready to meet tomorrow's needs.

There are many advanced contacts and contact materials already in commercial production at General Plate, just as there are always new ideas in contacts and contact materials under development — all for the purpose of providing maximum contact performance at minimum cost.

Here are a few advanced contact ideas which are now in production at General Plate.

Clad Electrical Contact Tapes — designed for high speed mechanized assembly — ideal for miniaturization — give increased performance at reduced cost.

New Metal Bonding Processes — offer improved contact materials — include silver cadmium oxides, refractory metal mixtures and platinum group metals, as well as all regular silver materials.

New Clad Button Projection — designed and produced to meet your specific application requirements — facilitate easier welding, provide better conductivity.

Single and Double Inlay-Overlay-Top-Lay — made by G.P.'s new exclusive P.T. cladding process — achieves permanent bonding of preferred contact metals to practically any malleable base metal without intermediate bonding agents.

Trimetal Clad Projection Welding Contacts — a copper conductor between contact face and backing — provides higher specific heat with lower surface temperatures — gives greater contact capacity and longer life at lower cost.

With 42 years of General Plate metal cladding experience guiding the emphasis now being put on G. P. electrical contacts, it will pay you to investigate. Technical data bulletins are available on request — let us know what types of contacts you are interested in.

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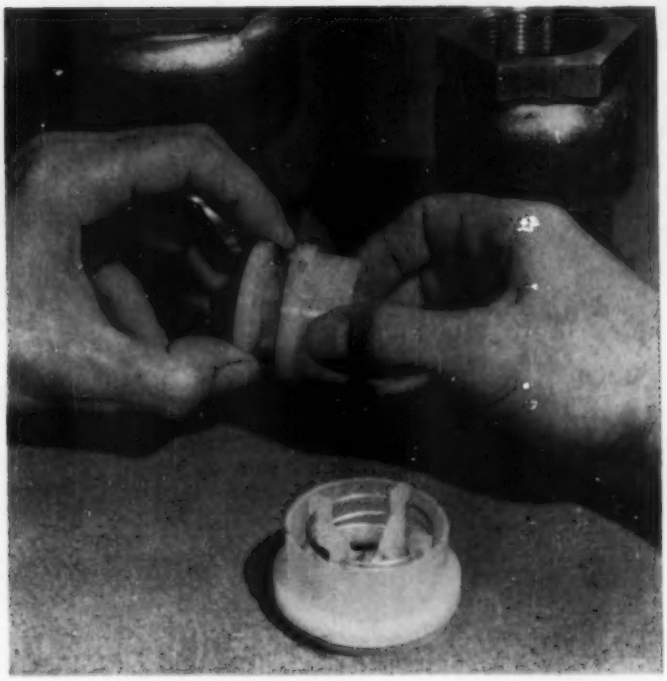
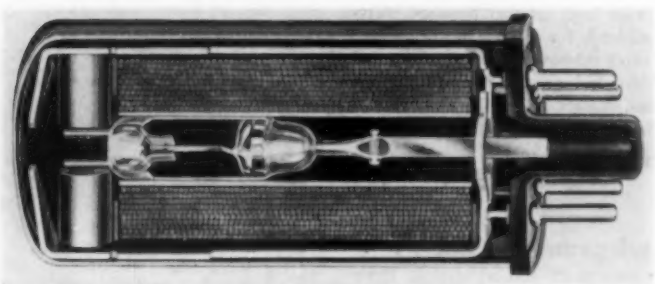


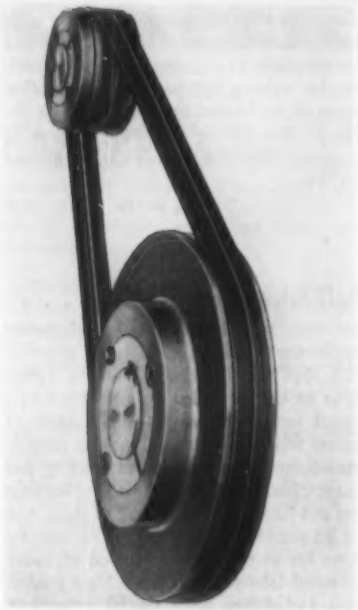
Pressure check-valve . . .
with continuous cap rotation eliminates incrustations and corrosion. Valve is patented nylon insert for cylindrical housing, incorporating a neoprene O-ring, stainless steel spring and self-tapping cadmium-plated screw. Valve cap rotates with natural spiraling motion as water, chemicals, petroleum, gases or air pass through. For pressure ranges from 250 through 500 psi. Said to operate efficiently in any position and to reseat perfectly after elongated rotation movement during operation. Installs quickly. Insert sizes range from ½ through 2 in. Total unit weight is from 0.80 through 6½ lb. Said to be priced less than comparable available units. **Check-All Valve Co, 818 E 22nd St Court, Des Moines, Ia.**

Circle 1, Reader Service Card



Sensitive mercury-wetted contact relay . . .
is biased with permanent magnets that are adjustable for single-side-stable or bi-stable operation at speeds to 200 cps or more. Sensitivity is said to be as low as ±2.5 milliw for bi-stable adjustment; as low as 5 milliw for a single-side-stable adjustment. Contact rating is 2 amp, 500 v, with a limit of 100 v-amp. 10-wk delivery. **C P Clare & Co, 3101 Platt Blvd, Chicago 45.**

Circle 2, Reader Service Card



Smaller, lighter belt drive . . .
reduced in width and OD handles majority of industrial drives with belts ⅜ in. wide. Drives are offered in two standard groove sizes to meet all except the largest industrial requirements. Sheave angles have been changed to fit new belt angles; increments in sheave dia have also been changed to give ample ratio range with min number of sheave sizes. Sheave of ⅜-in. nominal top width size, from 1 to 10 grooves, are for drives from 1 to 50 hp; ⅝-in. sheaves take from 3 to 10 belts and handle drives up to 200 hp. Max speed is 6000 fpm, compared with 5000 fpm for present V-belts. Tapered bushings on pulleys provide quick and secure shaft mounting. V-belts have a crowned top and concave sidewalls, with tension member of high-strength synthetic fibers. 3- to 50-hp drives from stock. Cost savings vary for different sizes, but, generally, drives are said to cost less than conventional units. **Dodge Mfg Corp, Mishawaka, Ind.**

Circle 3, Reader Service Card

Heavy-end aluminum pipe . . .
produced through a new extrusion process offers increased strength and thickness at pipe ends where welded or threaded joints are made, while utilizing less metal in pipe body. Operating pressures equivalent to standard pipe, with cost savings ranging by pipe size to 27% are said to be possi-

. . . CONTINUED ON PAGE 76

ble. Offered in selected sizes equivalent to many standard Schedule 40 and 80 sizes. Extrusion process is said to be flexible and can be adapted to wide range of diameters and wall thicknesses. Pipe ends are identical to those of standard pipe and are adaptable to grooving, threading, beveling for welding and preparation for other types of mechanical fittings. 3 to 4-wk delivery. Pricelist on Schedule 80 pipe is available. **Reynolds Metals Co, Richmond 18, Va.**

Circle 4, Reader Service Card

Self-lubricated bearings . . .

are made of Teflon fibers. In automotive application, bearing consists of spherical ball stud around which a woven Teflon fiber socket is molded on assembly into a metal housing. Complete elimination of grease fittings are claimed, making possible maintenance-free automotive steering and suspension. Road tests show that bearings are not harmed by dust, mud or slush. Use in jet aircraft has indicated fabric bearings have life of up to 10 times that of metal-to-metal lubricated bearings. Mass production techniques, using special equipment, have brought cost of bearing down to that of presently available conventional bearings. **American Metal Products Co, Linsdale Ave, Detroit 4.**

Circle 5, Reader Service Card

Thermoplastic for molding . . .

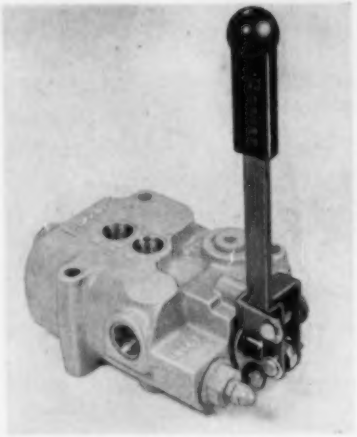
is a copolymer of styrene and methyl methacrylate. Said to have excellent clarity and processability, and to weather well, as well as to be tough, have good strength, heat resistance and light stability. The first member of this new family of plastic molding materials, trademarked Zerlon 150, is available in granular form. Priced at 49 to 50½¢ a lb, depending upon quantity, this copolymer is expected to compete with a variety of transparent thermoplastic molding materials. Material is fabricated like higher-heat-resistance formulations of polystyrene and can be processed on conventional equipment. May be molded or extruded. **Dow Chemical Co, Midland, Mich.**

Circle 6, Reader Service Card

Nickel-cadmium cells . . .

for min power requirements weigh ¼ oz and measure ⅞ in. dia. Hermetically sealed units were designed for miniature and subminiature electrical and electronic applications where min power requirements are needed. Sintered-plate cells are rechargeable by constant current equal to $\frac{1}{10}$ of normal capacity. Cells are said to be maintenance-free, non-gassing upon recharge, to require no filling or electrolyte, to operate at normal temperature range, and have a low internal resistance that allows discharge currents up to 10 times capacity. Can be combined into batteries of any desired voltage. **Gulton Industries Inc, 212 Durham Ave, Metuchen, NJ.**

Circle 7, Reader Service Card



1-spool control valves . . .

with handles for general-purpose hydraulic applications are offered in three capacities, with nominal ratings of 12, 20 and 40 gpm. Max recommended working pressure is 2000 psi. Valves are said to have low pressure drop and good metering, to provide precise positioning, smooth starting and stopping, or stepless control of speed in mechanism operated by hydraulic system. Integral check valve prevents load drop when changing spool operating positions. Externally adjustable relief valve has low pressure rise from crack to full flow. One-piece cast body is compactly designed with large internal passages. Ports are machined for SAE straight thread O-ring connections, eliminating tapered pipe thread leakage and danger of casting distortion. **Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 8, Reader Service Card

Integral gearmotor line . . .

in concentric-shaft and right-angle types for integral-hp motors through 100 hp and a line of fhp integral-type right-angle gearmotors are available with either open or totally enclosed motors, double and triple reduction in standard ratios. One-piece, corrosion-resistant, cast-iron housing and rabbet-fit motor flange are said to result in positive alignment of motor and gears regardless of mounting position. Ratio changes are simplified by use of one low-speed gear set for each drive size. **Allis-Chalmers Mfg Co, Milwaukee 1.**

Circle 9, Reader Service Card

Automatic clutch . . .

for severe service requirements in the 12- to 35-hp gasoline engine field. Constructed with three basic parts. Design provides 360° effective lining area with equal wear distribution. Said to have rapid heat dissipation and sealed ball bearings. Lining can be replaced in minutes by unskilled operator without special tools and needs no adjustment. **Salsbury Corp, 1161 E Florence Ave, Los Angeles 1.**

Circle 10, Reader Service Card

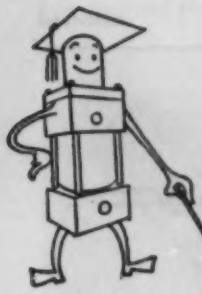
Sight glass . . .

has the word "full" printed on bottom part of glass and is visible only when refrigerant or other gas is at full charge. When level is low, word is blurred beyond recognition. Sealed by brass-to-glass fusion to eliminate leakage. There are no gaskets, joints or solder anywhere in sight glass. Available with male-male or male-female

. . . CONTINUED ON PAGE 78

Miller

FLUID PRESSURE BOOSTERS

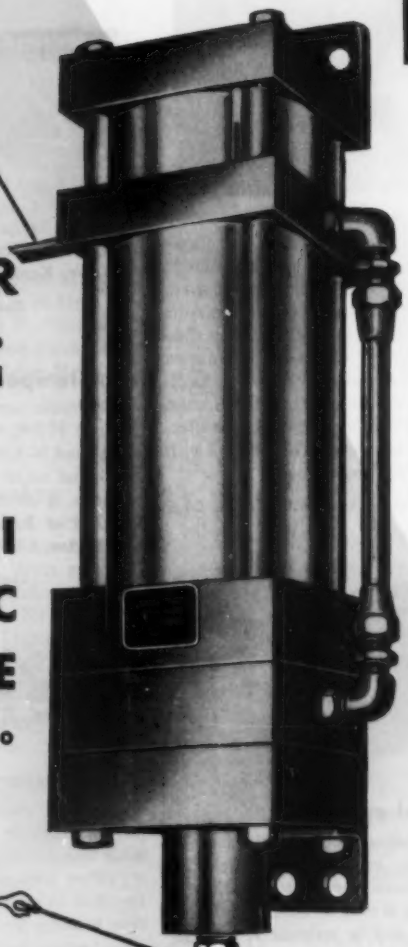


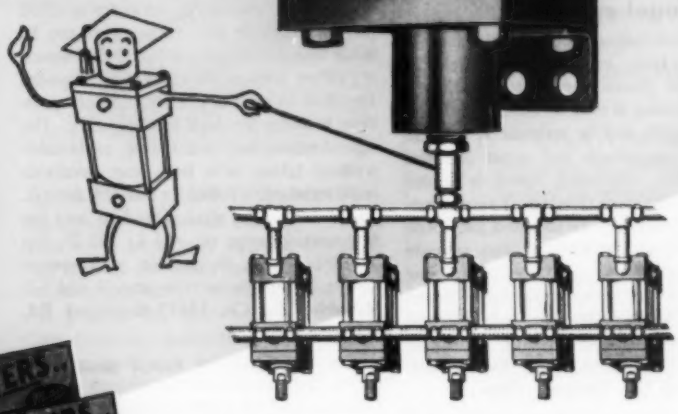
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

Output Range: 200 to 10,000 psi Fluid





- Save space, weight and investment cost by replacing pump installations in many applications
- Less costly to install, operate and maintain
- Hold pressure indefinitely without the motion and heat generation of ordinary pump circuits
- Provide—at point of cylinder thrust—more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery, Miller offers 5" bore 25 to 1 ratio boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.

ESPECIALLY RECOMMENDED FOR

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and similar applications

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Other Miller products include: Air Cylinders, 1½" to 20" Bores, 250 psi operation; Job-Rated Hydraulic Cylinders, 1½" through 14" Bores, 500-2500 psi operation; Power-Packed Hydraulic Cylinders, 1½" through 12" Bores, 3000-5000 psi operation. Available in all mounting styles and in single and double rod end.

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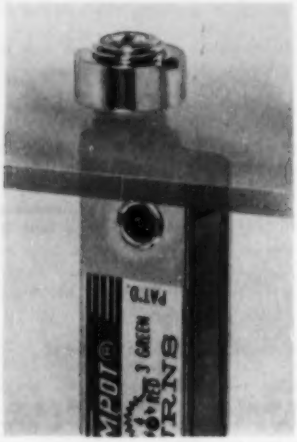
connections in standard sizes from ¼ to ½ in. ⅜-in. size is available only in male-male connections. **Ansul Chemical Co, Marinette, Wis.**

Circle 11, Reader Service Card



Potentiometer actuated . . .

by lead screw that extends through 0.2 in. mounting panel hole. Available in resistances of 100 to 50,000 ohm, units will operate reliably from —85 to 347 F. Power is rated 1 w to 158 F. Weighs about 0.3 oz and measures 0.23 x 1.32 x 0.24 in. **Bourns Laboratories Inc, PO Box 2112, Riverside, Calif.**

Circle 12, Reader Service Card

Subminiature time delay . . .

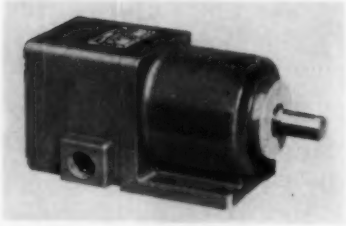
relay has a seated height of ⅞ in. above mounting panel and withstands continuous 20-g vibration at frequencies to 1000 cps. Contacts are SPST, normally open or closed, and rated 2 amp, resistive, at 115 v ac or 28 v dc. Thermal time delays are factory-set and hermetically sealed. Offered in 10 standard delays from 2 to 75 sec and for standard heater voltages of 6.3, 28 and 115 v. There are said to be no resonances in frequencies to 1000 cps. For ambient temperatures to 185 F for continuous energization; to 257 F for energization to 3 min. Hooked terminals are provided. Dimensions are ¾ in. dia x 1 $\frac{5}{16}$ over-all height. Weighs about ¾ oz. **G-V Controls Inc, Okner Parkway, Livingston, NJ.**

Circle 13, Reader Service Card

Flexible, plastic wire tie . . .

has ratchet-like design that makes it self-adjusting to wide range of wire bundle dia. Said to reduce tying time by about 30%. Tie is also fungus- and moisture-resistant. Tooth form allows bending to low limit of $\frac{1}{32}$-in. radius, while notched leader facilitates gripping tie for tightening. Double tooth is used in buckle to obtain ratchet-holding ability claimed almost equal to basic tensile strength of strap. V-ridge along underside of tie prevents sideslip. Flat leader surface eliminates danger of cutting into insulation of bundles. Special plier has been developed to facilitate gripping the tie and trimming excess strap after installation. **Westinghouse Electric Corp, Component Products Dept, 4-S-18, East Pittsburgh, Penna.**

Circle 14, Reader Service Card



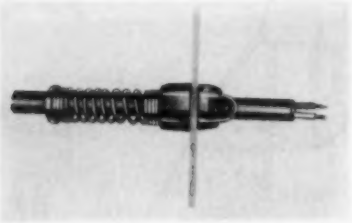
Centrifugal switch . . .

with over-all adjustable speed range of 70 to 5000 rpm, is housed in enclosure molded of glass-fiber-reinforced polyester resin. Housing is said to withstand severe shock impacts and be resistant to acid, alkali, salt compounds and moist corrosive atmospheres. Operating speed is adjustable while switch is running. Two separate sets of contacts can be adjusted for operation at different speeds so two separate operations can be controlled from one speed-sensitive switch, permitting performance of two functions at two different speeds. Switch is permanently lubricated. Measures 7¾ x 3 $\frac{5}{16}$ x 3¾ in. **Euclid Electric & Mfg Co, Madison, Ohio.**

Circle 15, Reader Service Card

Nylon strain-relief bushing . . .

for SJ wires and heavy-duty heater cord features a positive wire grip and nylon insulation to protect the wire from heat, vibration, pull and torque. Special spring locks unit and prevents sharp right-angle bending, excessive wire flexing and chafing at chassis entrance. For rapid assembly, bushing is hinged with flexible nylon web that snaps and locks in chassis hole. Bushings have UL and Canadian Standard Assn approval. Samples will be sent on receipt of wire size. **Heyman Mfg Co, 100 Michigan Ave, Kenilworth, NJ.**



Circle 16, Reader Service Card

High-temperature O-rings . . .

for hydraulic service in temperatures from —65 to 275 F. The rings are molded of compound N-304-7, a synthetic rubber material that meets applicable military specifications, in all standard sizes. **Parker Seal Co, Div of Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 17, Reader Service Card

High-pressure relief valve . . .

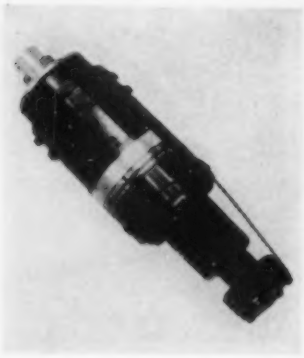
is for in-line service for pressures to 5000 psi. Adjustment over entire range can be made by external nuts, without disconnecting either pressure or return line. Provides free flow in reverse direction. Pilot operation provides for high flow capacity. Design contains only one O-ring, replaceable without taking valve from line. Available with standard 37° flare or flareless fittings. Made of stainless steel. Standard unit has temperature range of —65 to 160 F. Up to 400 F max is possible with special O-ring. Available in tube sizes 8 and 12. **Republic Mfg Co, 15655 Brookpark Rd, Cleveland 35.**

Circle 18, Reader Service Card

Electromechanical brake . . .

is operated through a solenoid. Brake is applied within 200 millisec after receipt of electrical signal and has holding torque of 300 in.-lb. Current is automatically cut off by microswitch after brake is energized. Brake must be manually released and reset by rotating a reset knob. Designed for emergency function in aircraft application, brake operates on 24-v dc power and draws

. . . CONTINUED ON PAGE 80



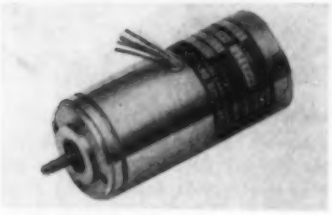
instantaneous current of 7 amp. Min firing voltage is 14 v. Operates in ambient temperatures of −65 to 165 F. Weighs 3.2 lb; measures 8 x 2¾ in. **Steel Products Engineering Co, Div of Kelsey-Hayes Co, Springfield, Ohio.**

Circle 19, Reader Service Card

Reset time-delay relay . . .

is multiple-pole unit available with various current ratings. Immediately resets at completion of delay cycle. Meets applicable military requirements. Standard mounting arrangements are offered. Size is 2.25 cu in.; weighs about 3 oz. **Branson Corp, 41 S Jefferson Rd, Whippany, NJ.**

Circle 20, Reader Service Card



Sizes 10, 11, 15 servomotors . . .

incorporate an inertial damper. Unit is said to be electrically equivalent to lead-lag network commonly used in servomechanism applications. Inertial damper is said to provide for max velocity constants line frequency insensitivity; no wiring or pickup problems; suppression of residual noise; noncritical adjustments and no loss in shaft output. Meets military specifications. Operates to 302 F. **Eastern Air Devices Inc, 381 Central Ave, Dover, NH.**

Circle 21, Reader Service Card

Cycling thermostat controls . . .

have shallow mounting depth and offer side access to terminals for servicing. Dial-within-a-dial circuit-selector switch is available with the controls, which are offered in two series. Various models provide up

(Continued on page 80)

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of new super-tough alloy
prolongs mainspring life indefinitely...

Of far-reaching benefit to users of mechanical timers is the development of a special steel which *virtually eliminates mainspring failure* . . . a significant "first" by MARK-TIME engineers that adds extra sales features to your product at no extra cost.

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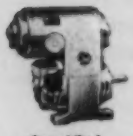

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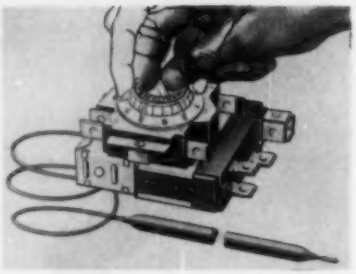
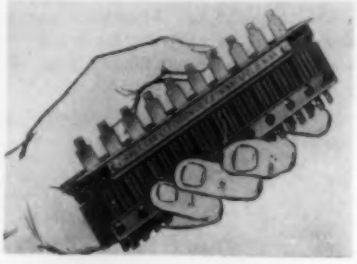


to four circuits with dial positions to open all circuits or close one or two circuits simultaneously. Four, six or eight dial positions are standard. Thermostat is rated 20 amp, full load, 78 amp locked rotor at 115 or 230 v ac; 20 amp at 250 v ac, noninductive. Manual rotary circuit-selector switch can be provided as a separate unit with standard solid ¼-in.-dia brass shaft. Standard application has opening for ¼-in. shaft inside a hollow ⅜-in. OD shaft, with smaller shaft dia available. Flush-mount switch. **Ranco Inc, Columbus 1, Ohio.**

Circle 22, Reader Service Card



Pushbutton switch . . .

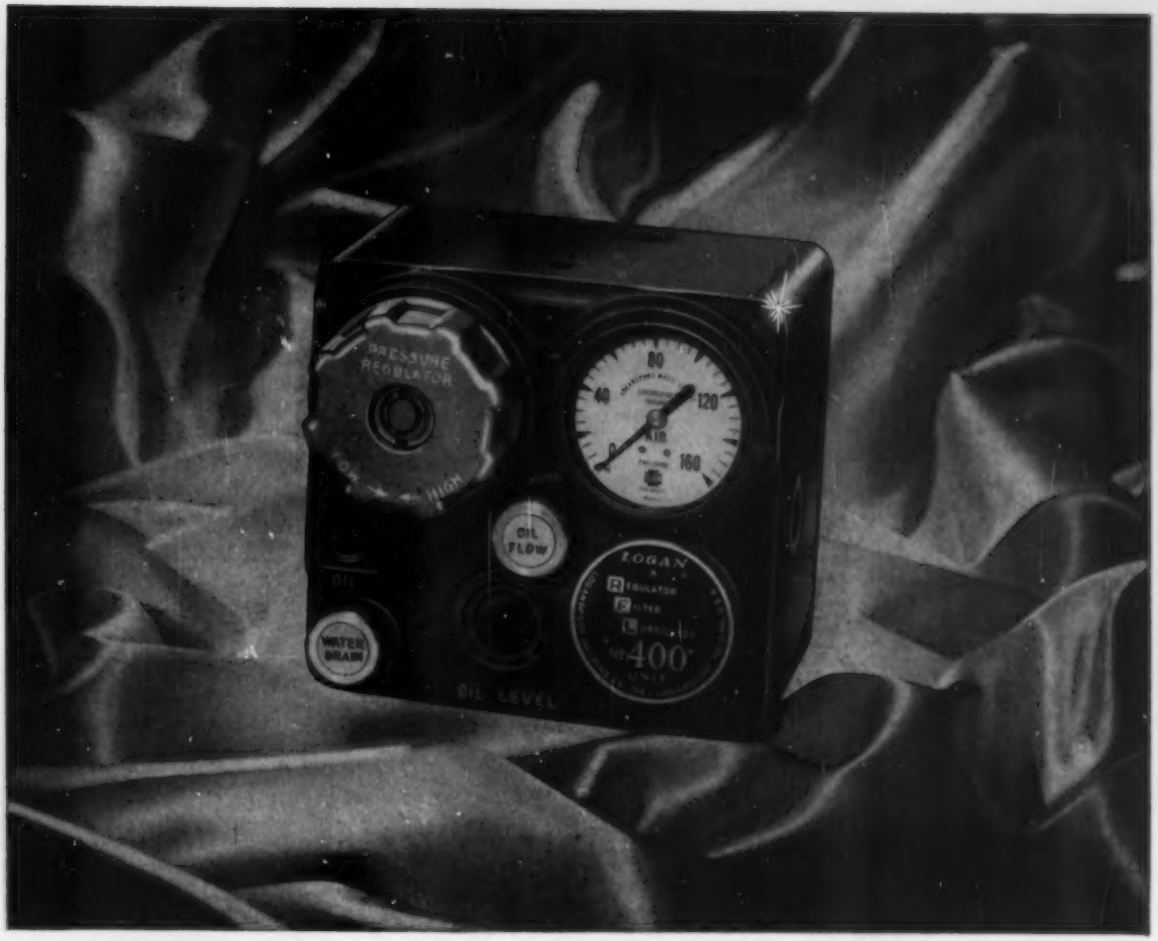
is said to have mean life of 1 million operations per station. Each station offers up to four type-A contacts rated at 100 milliamp at 150 v dc. Switch may be ganged, interbussed, cross-interlocked; and is available with locknut and automatic release solenoids. Normally supplied with tab or solder terminals. Contacts are made of bifurcated palladium, supported by nickel full hard heat-treated springs. Contact pressure is 15 gm min per contact. Max operating pressure required is 900 gm with no button switch interlocking; 1100 gm with interlocking to another switch. **American-Monarch Corp, American Electrics Co Div, 2801 37th Ave NE, Minneapolis 18.**

Circle 23, Reader Service Card

Speed changer kit . . .

provides 29 ratios from 1:1 to 44:1. Housings, bearings, gears and shafts may be reused. The 48-pitch, 20° pressure angle spur gears are case-hardened steel. Input

(Continued on page 82)



Illustrated—Logan Model 400 RFL Unit

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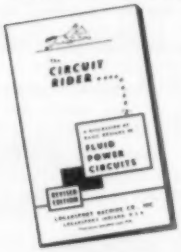
Logan RFL Unit, the designers choice for over a decade! Protects your air-powered equipment . . . regulates pressure . . . filters air . . . lubricates air. Adds years of dependable performance.

New Model 400, illustrated above, is a companion model to the well-known Model 600.



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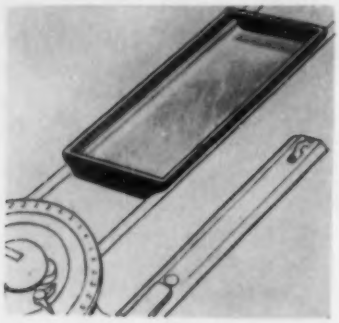
and output shafts run in two ball bearings on each shaft; countershafts run in ground needle bearings. Torque is rated 130 in.-oz max at low-speed shaft; speed is 10,000 rpm max at high-speed shaft; horsepower is 0.1 hp max at low-speed shaft. Tube of grease lubricant, allen wrench, instructions and a gear gage are also included in kit, which has carrying case. Additional parts available to augment kit. **Metron Instrument Co, 432 Lincoln St, Denver 3.**

Circle 24, Reader Service Card



Wood pencil trays . . .

have rounded corners and are carved in Norway from birch or mahogany. Grain pattern is finished with clear plastic lacquer. For use with horizontal drafting machines. Price is $2.50 each. **Best Yet Products, Box 9092, Chicago 90.**

Circle 25, Reader Service Card

High-speed whiteprinter . . .

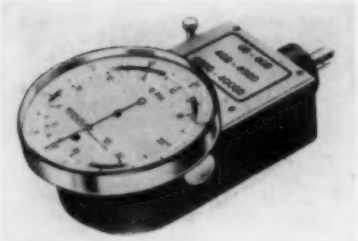
is for large-scale black-on-white reproduction. Unit employs fumeless, clean diazotype process. Two operators, each running different types of sensitized materials, can use machine simultaneously. Split shade on fast-printing 7500-w lamp, variable to 5000 w, provides correct light for each print. Large sheets and roll stock cannot shift on feedboard as they are held in place by air vacuum ports in and below feedboard. Unit and feedboard heights adjustable. Takes sheets and roll stock to 42 in. wide by any length. Mechanical speed is up to 75 fpm. Front or rear print delivery is achieved by a selection lever. Operates on 230-v, single phase, 60-cps ac with max operating current of 64 amp. **Charles Bruning Co, Mount Prospect, Ill.**

Circle 26, Reader Service Card

Desktop analog computer . . .

performs functions of general-purpose analog equipment. Affords versatile and time-saving system for solving design, analysis or control problems. Measures voltage variations, representing physical variables of problems. Parameters can be altered by a dial. Basic installation is about $2500 for analog computer with 10 chopper-stabilized amplifiers, power supplies, controls and metering circuitry, potentiometer strip, problem board and assorted components. **Donner Scientific Co, Concord, Calif.**

Circle 27, Reader Service Card



Centrifugal hand tachometer . . .

is said to be accurate to 0.5%. By use of reflecting mirror on dial, parallax errors are eliminated. Pointer rotates 675°, providing a scale length of over 13½ in. though dial is only 2⅞ in. dia. Instrument weighs 12 oz. Stop button locks pointer at any speed as reminder of reading until next speed check. In three ranges, measuring from 40 to 40,000 rpm or 20 to 20,000 rpm. **Boulin Instrument Corp, 10 First St, Pelham, NY.**

Circle 28, Reader Service Card

Sensitized film . . .

produces duplicate originals that retain flexibility and transparency almost indefinitely and are impervious to water and perspiration. Intermediate Mylar-base film is diazo-sensitized on glossy reverse side, permitting repeated eradication without affecting front matte finish. Lines from original drawing are eradicated with cotton dauber dipped into solvent chemical or with typewriter eraser and shield. Tensile strength is 20,000 psi; flex-life, 20,000 cycles. Available in sepia and black line. Samples are offered. **Eugene Dietzgen Co, Dept P-10, 2425 N Sheffield Ave, Chicago 14.**

Circle 29, Reader Service Card

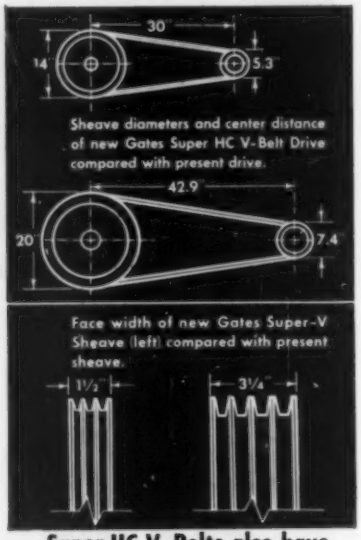
How savings multiply with new Gates Super HC V-Belt Drive

The cost of a new Gates Super HC V-Belt Drive is as much as 20% less than the cost of a drive of comparable hp using present V-belts. But the lower cost of the drive itself is only the initial *purchasing* economy.

Further economies are realized on drive equipment, such as housings and bases — economies in materials, production time, shipping costs.

Shown below are space savings of a typical installation . . .

	Present Drive	Super HC Drive
DriveR Sheave	7.4	5.3
DriveN Sheave	20.0	14.0
Center Distance	42.9	30.0
Belts	4-B128	3-3V900



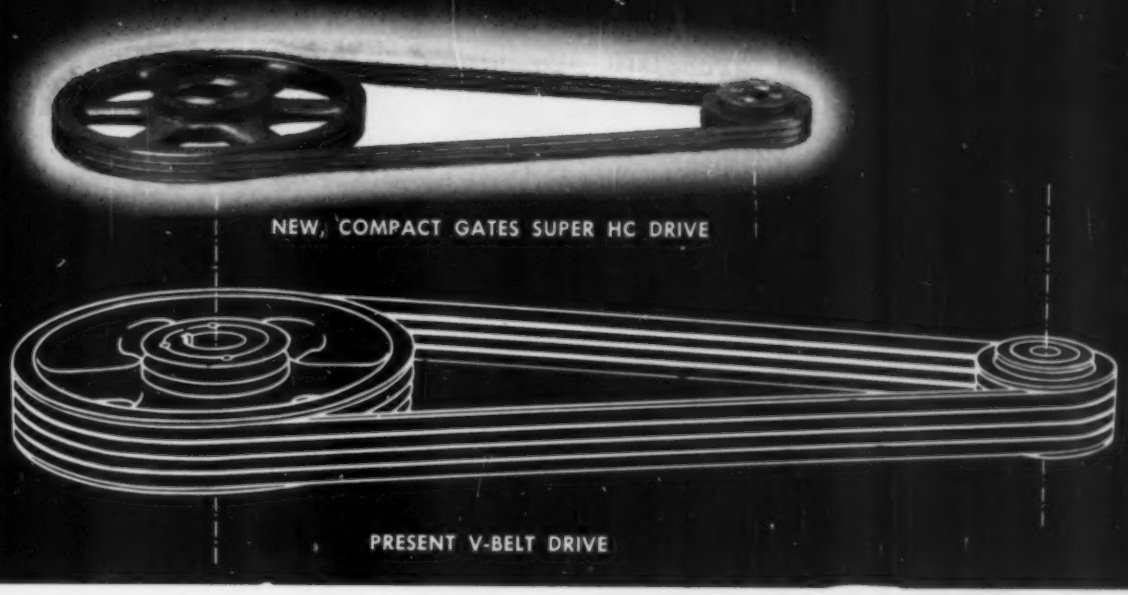
Super HC V-Belts also have these important Gates features...

1. **Flex-Weave Cover** (U. S. Pat. 2519590) A Gates exclusive. Makes cover more flexible . . . prolongs belt life.
2. **Concave Sidewalls** (U. S. Pat. 1813698) become straight as belt bends insuring uniform contact with sides of groove. Uniform contact means less wear . . . far longer belt life.
3. **High Electrical Conductivity** is built in for safer drives in explosive atmospheres.
4. **Oil, Heat and Weather Resistance** is insured by use of special rubber compounds.

Gates

CIRCLE 132 READER SERVICE CARD

New high capacity V-belt revolutionizes drive design



Makes drives far more compact... cuts cost as much as 20%

Here is a major advance in the field of power transmission — the fully proved Gates Super HC V-Belt, developed in the world's largest belt-testing laboratories at The Gates Rubber Company.

With the Gates Super HC V-Belt, you can have the lowest-cost, lightest-weight, most compact multiple V-belt drive you can put on any machine! Sheave diameters can be reduced up to 50%, sheave widths 30% to 50%, center distances 20% and more!

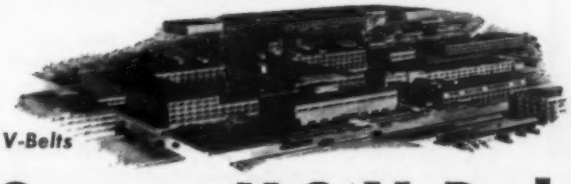
On new drives, the cost of a Gates Super HC V-Belt Drive is as much as 20% less than present V-belt drives of the same hp capacity!

Learn More About The Cost-Saving Super HC Drive

For detailed information on the Super HC Drive, contact your nearby Gates distributor or Gates Office for new booklet, "*The Modern Way to Design Multiple V-Belt Drives.*" For utmost space, weight and dollar savings in new drives or drive replacements, specify Gates Super HC V-Belts and Sheaves. Stocks immediately available in principal industrial centers.

The Gates Rubber Company Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates
World's Largest Maker of V-Belts



Gates Super HC V-Belt Drives

CIRCLE 133 READER SERVICE CARD

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Smooth Power

AC MOTORS

Advanced Motor Designs

that meet the demands of the most exacting requirements

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MODEL B, FOUR POLE, FOUR-COIL SHADED POLE MOTOR

Designed for long life and dynamically balanced for extremely quiet operation. Self aligning, self lubricating bronze bearings, baked, varnish-impregnated windings, ample oil reservoir located for easy lubrication. Smooth, quiet — field proven!

SPECIFICATIONS

MODEL	HP 1500 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	Wt. Lbs.
B-5-CW B-5-CCW	1/80	3.5	11	1735	2.0
B-8-CW B-8-CCW	1/50	4.0	14	1750	2.7
B-10-CW B-10-CCW	1/40	4.7	18	1750	3.1
B-12-CW B-12-CCW	1/35	4.7	20	1760	3.4

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

INDUSTRIAL CONTROLS—Catalog C101-la, 84 pp. Describes and illustrates over 9000 electric, electronic and pneumatic controls, with specifications, performance data and ratings. Discusses applications, hp ratings and electric controller switch ratings. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.

Circle 30, Reader Service Card

SELECTING A SLIDE RULE—Booklet, 24 pp. Guide describes slide-rule scale designs and arrangements; woods, glass and synthetic materials used in construction; and teaching aids and accessories for the slide-rule. Also describes a variety of rules available from this company. Keuffel & Esser Co, Adams and 3rd Sts, Hoboken, NJ.

Circle 31, Reader Service Card

DESIGN-TRACING TEMPLETS — Package of over 14 templets can be used for breadboard layouts, prototypes, design production, technical sketching and part drawings. Offered free. Pic Design Corp, Sub of Benrus Watch Co Inc, 477 Atlantic Ave, East Rockaway, NY.

Circle 32, Reader Service Card

FABRICATING NICKEL-BASE ALLOYS—Booklet, 36 pp. Presents step-by-step procedures and recommendations for welding, forging, forming, machining, grinding, brazing, heat-treating, descaling and pickling. Also includes information on lining vessels and corrosion surfacing. Haynes Stellite Co, Kokomo, Ind.

Circle 33, Reader Service Card

MODULAR INSTRUMENT ENCLOSURES—Catalog 201 and price list, 60 pp. Ten sections tell how system works, describe basic frames, components, mounting, cooling equipment, bench cabinets, desks, expandable cabinets, ordering, policy and drawings and specifications. Amco Engineering Co, 7333 W Ainslie St, Chicago 31.

Circle 34, Reader Service Card

CYLINDRICAL CLAMPS—Catalog, about 70 pp. Discusses construction, operation and advantages of tapered disks made from slotted elastic material and for use as fastener and for clamping. Includes specifications, drawings and price-list. Karl A Neise, US representative, 404 4th Ave, New York 16.

Circle 35, Reader Service Card

TEFLON FOR MACHINING—Stock list and handbook C-1, 28 pp. The 1087 sizes of Teflon tubing and rod available for machining into parts are priced. All stock prices are on a unit basis. Also details machining methods, speeds, feeds and tool design. Included are methods for engine lathe and automatic screw machine work. Tells how to make various parts. Halogen Insulator & Seal Corp, 9960 Pacific Ave, Franklin Park, Ill.

Circle 36, Reader Service Card

HEAVY-DUTY LIMIT SWITCHES—Catalog 84, 16 pp. Covers three types of industrial switches. Lists switches with variety of contact arrangements, for ac or dc applications. Several actuator designs in each type are shown. Includes specifications, ratings, dimensions, mounting diagrams, dimensional drawings and schematics. Micro Switch, Freeport, Ill.

Circle 37, Reader Service Card

STANDARD AND SPECIAL INSTRUMENT CASES—Design manual 401G, 20 pp. Contains design information, drawings on 120 basic sizes and types, materials and specification cross-referenced to military requirements. Each size is illustrated with an engineering drawing. TA Mfg Corp, 4607 Alger St, Los Angeles 39.

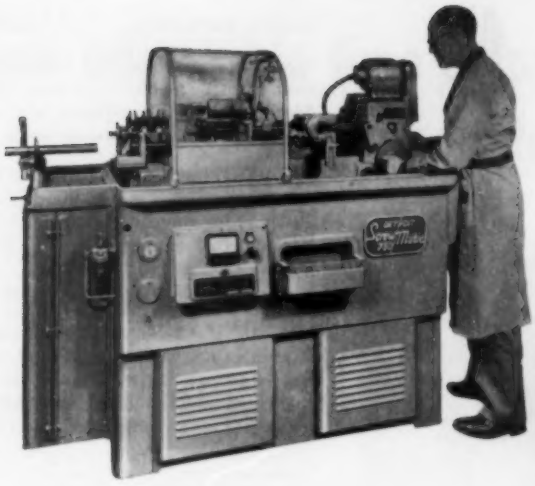
Circle 38, Reader Service Card

ELECTROHYDRAULIC SERVOSYSTEM COMPONENTS—Bulletin 36100, 8 pp. Illustrates and describes construction and principle of operation of plungerless valve design. Bulletin 36200, 4 pp. Covers specifications, capabilities and operation of universal power amplifier. Bulletin 36300, 4 pp. Illustrates and describes construction and specifications of preset dial units. Bulletin 36400, 4 pp. Illustrates several forms and types of custom-built amplifier and control panels for operating electrohydraulic servo systems. Oilgear Co, 1570V W Pierce St, Milwaukee 4.

Circle 39, Reader Service Card

PVC PIPE AND FITTINGS—Brochure S-1032, 12 pp. Contains sales and technical information, including advantages and properties, general characteristics and applications, physical properties, installation instructions, flow-rate charts and specifications for schedules 40 and 80 pipe and PVC fittings. Also, chemical resistance

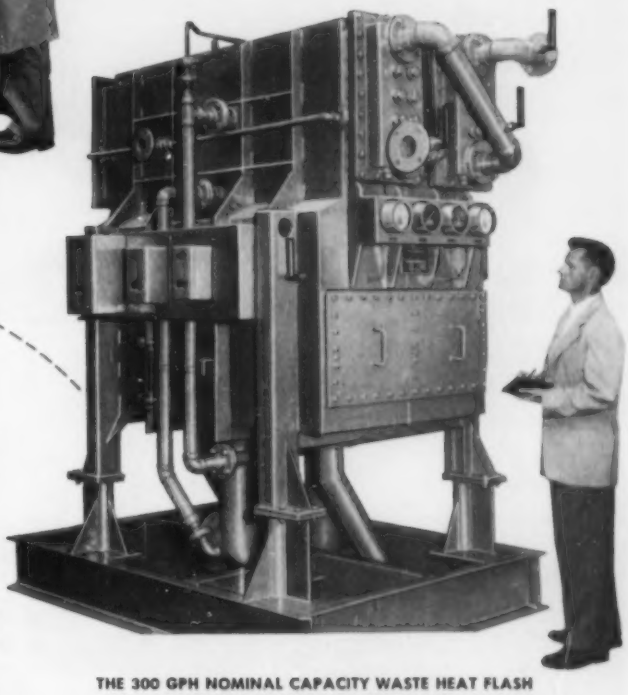
(Continued on page 86)



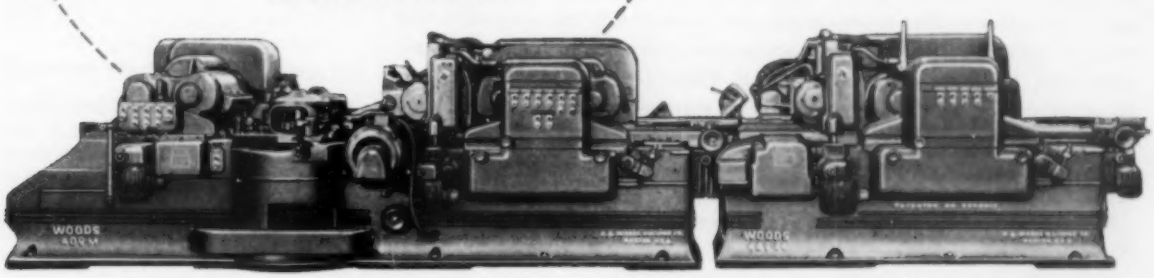
THE DETROIT SCREWMATIC 750 MANUFACTURED BY THE GEAR GRINDING MACHINE COMPANY INCLUDES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AS ORIGINAL FACTORY EQUIPMENT.

CUTLER·HAMMER
CONTROL
C-H

Choice of the leaders ...the mark of better machines



THE 300 GPH NOMINAL CAPACITY WASTE HEAT FLASH EVAPORATOR BUILT BY CLEAVER BROOKS COMPANY IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AS ORIGINAL CONTROL EQUIPMENT.



You too will find it pays to use Cutler-Hammer Motor Control; it installs easier, works better, and lasts longer.

For detailed information write Dept. A-249.
CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.

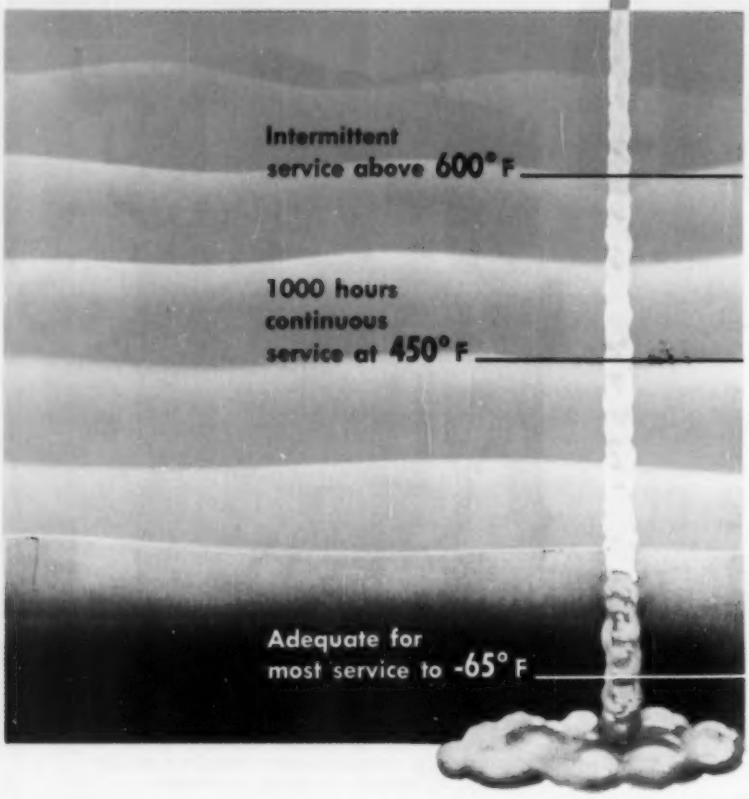
THE S. A. WOODS MACHINE COMPANY 409M STREAMLINED FAST FEED HEAVY DUTY PLANER AND MATCHER COUPLED WITH THEIR 469M HEAVY DUTY BLANKER IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND OIL-TIGHT PUSHBUTTONS.

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

"O" Ring Compound 17107

PRECISION Development increases temperature range of "O" Rings



This dramatically new Precision "O" Ring compound seals effectively over the range of −65° F up to 500° F with this maximum range dependent on service conditions. Has exceptionally low compression set, unusually low volume change, resistant to destructive chemicals, exotic fuels, synthetic lubricants, hydraulic fluids and ozone. Meets the most severe military specification for high temperature service elastomers. (Write for data.)

Precision Compound 17107 (based on DuPont Viton A) is typical of the many developments that have made Precision Rubber the recognized leader of the industry.

For the answer to your sealing problems ask for the services of the Precision Engineer.

"O" Rings—Rubber Bonded to Metal—Rubber Seals and Gaskets

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Dept. 3, Oakridge Drive, Dayton 7, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

Catalogs and Bulletins.....continued

chart that lists about 350 reagents and their effect upon PVC pipe and fittings. Mueller Brass Co, Port Huron, Mich.

Circle 40, Reader Service Card

THERMOPLASTIC KNOBS—Booklet, 6 pp. Photos, diagrams and dimensions of 28 knobs, ranging from ⅛ to 2¾ in. dia. Waterbury Companies Inc, 555 Washington St, Waterbury 20, Conn.

Circle 41, Reader Service Card

MECHANICAL SEALS—Bulletin, 4 pp. Describes line of precision shaft seals. Ranges for standard types are given and engineered models offered for other applications. Borg-Warner Mechanical Seals, Div Borg-Warner Corp, PO Box 2017, Terminal Annex, Los Angeles 54, Calif.

Circle 42, Reader Service Card

PRECISION-ANNEALED PHOSPHOR BRONZE—Bulletin, 4 pp. Discusses effects of precision annealing technique on spring temper phosphor bronze sheet and strip. Enlarged photomicrographs compare grain structure with structure of ordinary annealed phosphor bronze. Some typical applications are pictured and advantageous characteristics are given. Waterbury Rolling Mills Inc, Waterbury, Conn.

Circle 43, Reader Service Card

PRECISION MECHANICAL COMPONENTS—Brochure, 4 pp. Gives specifications and performance data on cams, synchros, mechanical differentials, oldham couplings and 10-w low-inertia servomotors. Ford Instrument Co, 31-10 Thomson Ave, Long Island City 1, NY.

Circle 44, Reader Service Card

FLEXIBLE SHAFTING—Bulletin 539, 8 pp. Discusses characteristics, applications and selection. Includes specification tables and selection information. F W Stewart Corp, Industrial Div, 4311-13 Ravenswood Ave, Chicago 13.

Circle 45, Reader Service Card

DRAFTING-ROOM EQUIPMENT—Catalog 15, 34 pp. Presents line of drafting tables and files. Gives specifications, special features. Hamilton Mfg. Co, Two Rivers, Wis.

Circle 46, Reader Service Card

CENTRALIZED CONTROL SYSTEMS—Bulletin 106, 16 pp. Design approach, materials, construction and facilities used in manufacturing centralized control and data-presentation systems. Panellit Inc, 7401 N Hamlin Ave, Skokie, Ill.

Circle 47, Reader Service Card

RUNNING GEAR—Catalog, 16 pp. Presents line of running gear, including spring-mounted casters and suspension systems. Covers design considerations, typi-

(Continued on page 88)

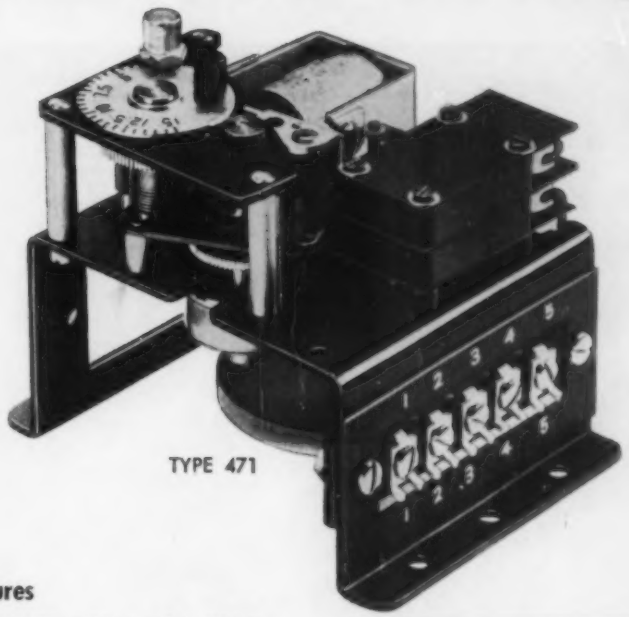
New adjustable time delay relay provides wide selection of time ranges

The new Cramer Type 471 Time Delay Relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. Through selection of external wiring connections, the unit offers broad application flexibility and excellent accuracy at modest cost. Some typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment of many kinds.

Operation

Type 471 is powered by a Cramer synchronous motor which drives precision-cut timing cams through a clutch, from a starting point set by a dial knob. The cams rotate at constant speed to a zero point, where the load switch is transferred. An instant later, a second cam opens the motor circuit. The clutch stays engaged, and the unit does not reset until the operator either opens the clutch circuit for the direct-clutch model, or closes the clutch circuit for the reverse-clutch model.

The direct-clutch unit resets automatically on power interruption, and repeats its complete cycle when power is restored. The reverse-clutch unit simply suspends operation and, when power returns, proceeds to complete the same time interval. Resetting is accomplished by a coil spring which drives the cam carriage back to a movable stop which is positioned by the dial knob. The stop location determines how quickly the cams will reach the switch actuation points, and so determines the timed interval.



TYPE 471

Features

TIME RANGES — 15 seconds to 24 hours.

ADJUSTMENT RANGE — 90% of full scale.

ACCURACY — within 2% of full scale.

RESET TIME — approx. ⅓ second or less.

LOAD SWITCHES — snap-acting SPDT, 10A 125V or 5A 250V AC, non-inductive.

MOTOR & CLUTCH — 115/220V, 25, 50 and 60 cycles. Reverse clutch optional.

GEARS — case-hardened steel, for life in excess of a million operations.

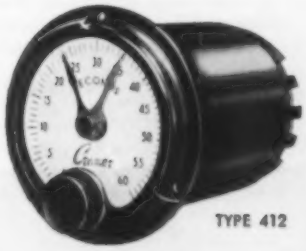
For details, write for your free copy of Bulletin PB-471.

TIME RANGES AND MINIMUM SETTINGS

TIME RANGE	DIAL DIVISIONS	MINIMUM SETTING
15 sec.	½ sec.	1.5 sec.
30 sec.	1 sec.	3 sec.
60 sec.	2 sec.	6 sec.
5 min.	10 sec.	30 sec.
15 min.	30 sec.	1.5 min.
30 min.	1 min.	3 min.
60 min.	2 min.	6 min.
2 hrs.	5 min.	12 min.
5 hrs.	15 min.	36 min.
12 hrs.	30 min.	1¼ hrs.
24 hrs.	1 hr.	2½ hrs.

FOR EXTREME ACCURACY PLUS WIDE SELECTION OF RANGES

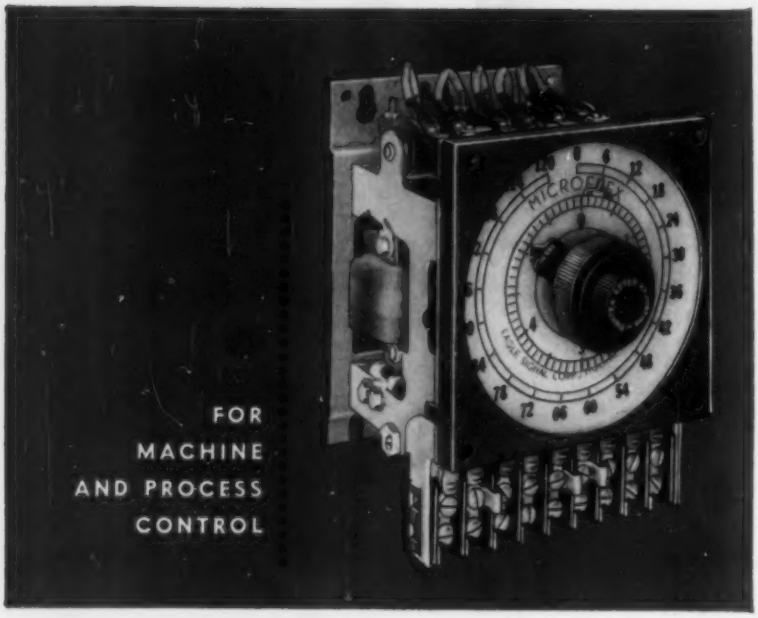
Type 412 performs essentially the same functions as Type 471, except that it is designed for panel mounting, extreme accuracy, heavier loads, and 100% adjustability over the entire time range of each unit. Eleven full-scale time ranges are available, from 6 seconds to 24 hours. Overall accuracy is within plus or minus ½ of 1% of full scale, exclusive of setting errors. Repeat accuracy is within plus or minus ¼ of 1% of full scale on 30 second and longer ranges, and ½ of 1% of full scale on faster timers. The fully enclosed dial carries a red pointer to indicate the setting, a black pointer to indicate timing progress. The open blade SPDT load switch is rated 15A 125V, 10A 250V AC, and can handle inrush currents up to 40 amperes. A second load, operating within 1% of full-scale time following the first load, can be controlled from the motor switch itself. Internal SPST seal-in contacts permit operation from a 1/10-sec. control pulse if desired. Direct or reverse clutch operation is as described for Type 471.



TYPE 412

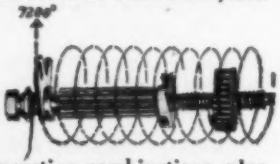
CRAMER CONTROLS
CORPORATION
Box 7, Centerbrook, Connecticut

EAGLE
Microflex Reset Timer



Accurate to 1 part in 1200

Time settings of pinpoint accuracy are a reality, thanks to the Microflex double dial. It takes one complete turn of the *inner* dial to advance the *outer* dial just one division. That's a 20-to-1 ratio, made possible by the patented Microflex threaded axle and pinion (see sketch). Examples of resultant accuracies are ± 1/60 of a second on a 20-second dial, and ± 1/10 of a second on a 120-second dial.



The Microflex Reset Timer is driven by a heavy-duty industrial synchronous motor. Contacts are tripped closed or open after a preset time interval. Starting and resetting are electrically controlled. Microflex offers over 150 timer operating combinations, plus a wide range of long or short time periods. It's ideal for applications like molding presses, dielectric heating, automatic mixing, die casting machines, machine tools and rubber curing.

Write for free Bulletin 110.

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. PE-159
MOLINE, ILLINOIS

Please send Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

Catalogs and Bulletins.....continued

cal applications, components and ordering information. Modern Caster Co, Rockford, Ill.

Circle 48, Reader Service Card

LABORATORY APPARATUS AND INSTRUMENTS—1959 catalog, 175 pp. More than 450 different pieces of equipment are described and illustrated. Indexed. Includes specifications, ranges, prices. Labline Inc, 3070-82 W Grand Ave, Chicago 22.

Circle 49, Reader Service Card

LAB AND FIELD TESTING FACILITIES—Bulletin 5801, 6 pp. Describes engineering facilities and services, covering such subjects as environmental studies, instrument calibration, reliability testing and failure analysis. United States Testing Co Inc, 1415 Park Ave, Hoboken, NJ

Circle 50, Reader Service Card

LIQUID AND PASTE ADHESIVES—Bulletin, 4 pp. Shows applications of adhesives which use room-temperature curing hardeners and heat-curing hardeners for high-temperature service. Includes glossary of adhesives. Furane Plastics Inc, 4516 Brazil St, Los Angeles 39.

Circle 51, Reader Service Card

STRAIN GAGES—Brochure, 4 pp. Tells how resistance bridge indicator is set up to provide a visual digital display with readout in any desired units. Also contains schematics and information on typical applications. Gives specifications. Datran Electronics, 1836 Rosecrans Ave, Manhattan Beach, Calif.

Circle 52, Reader Service Card

SAFETY RELIEF VALVE — Catalog Sheet, 1 pp. Describes valve for cryogenic, high pressure gas, hydraulic and fuel service. Specialty Engineering Co, 264 W Fairview Ave, San Gabriel, Calif.

Circle 53, Reader Service Card

COMPRESSED-AIR FILTERS — Bulletin GEO-507, 4 pp. Includes technical information and charts on flow characteristics, dimensions and metals in which filters for compressed air and other gases are made. Commercial Filters Corp, 2 Main St, Melrose, Mass.

Circle 54, Reader Service Card

PLASTIC-COATED WIRE AND CABLE—Folder, 6 pp. Lists wires and cables in a variety of conducting, insulating, jacketing, shielding and armoring materials. Chester Cable Corp, 175 Oakland Ave, Chester, NY.

Circle 55, Reader Service Card

CERAMIC TRANSDUCERS — Bulletin X-103, 8 pp. Covers properties and applications of high-temperature, piezoelectric ceramic transducers. Advanced De-

(Contiued on page 91)

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland–Absolute Alignment

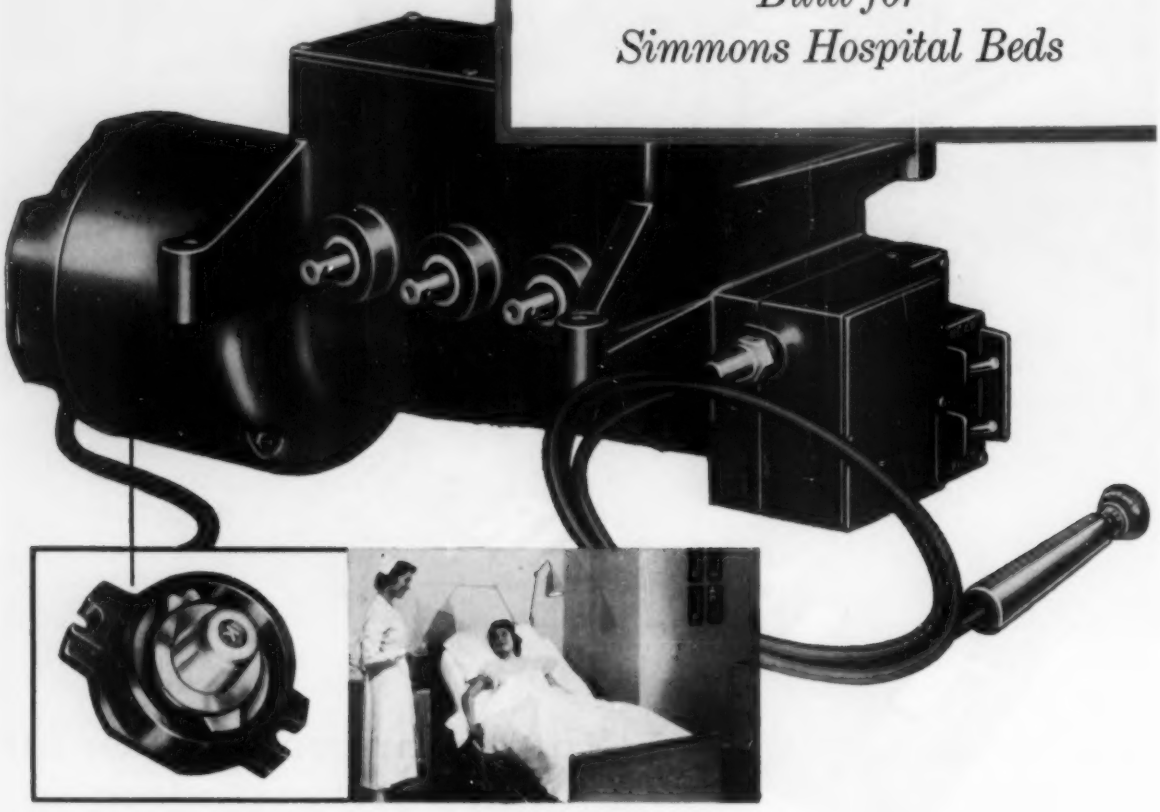
10 Piston Rod, Extra Strong–Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

Because
Safety is a Must...

FRANKLIN USES KLIXON Protectors in their Inst-O-Verse* Motors

Built for
Simmons Hospital Beds



The Simmons Company's "Sim-Matic" Bed provides maximum patient comfort by permitting personal, finger-tip control of bed positions. The Franklin Electric 3 output shaft gear motor, shown above, is built for such hospital bed operation. It is equipped with "Inst-O-Verse" mechanism which allows minute adjustment of the bed by providing instant reversal of the motor.

Because safety is a must, Franklin Electric Co., Inc., uses KLIXON Protectors in their hospital bed motors as well as in other motors.

Here's the way they put it . . .

"Dependability is a major requirement of equipment used in hospitals, and dependable motor protection requires the positive action afforded by a KLIXON *Protector that cuts off power when conditions arise that would otherwise result in damage and loss of motor service. Patient safety also requires the positive protection provided by the* KLIXON *Protector."*

You, too, can keep motor-driven equipment operating dependably by specifying and using KLIXON-protected motors. They reduce maintenance costs, service calls, repairs and replacements. The additional cost is low . . . with exceptionally worthwhile benefits for both you and your customers.

*®Franklin Electric Co., Inc.

METALS & CONTROLS CORPORATION
Spencer Division
3801 Forest Street, Attleboro, Mass.
KLIXON®

velopment and Systems Div, Gulton Industries Inc, 212 Durham Ave, Metuchen, NJ.

Circle 56, Reader Service Card

AIR MOTORS—Bulletin 5072A, 16 pp. Covers over 100 air motor units. Lists specifications and includes dimensional drawings. Eight case histories are illustrated, and design and construction features are shown in cutaway views. Also, includes typical power curve. Ingersoll-Rand, 11 Broadway, New York 4.

Circle 57, Reader Service Card

PIPELINE AFTERCOOLERS—Bulletin 302.6K1, 8 pp. Specifications on 54 models for operating pressures to 125 psig are given. Construction features are shown in cutaway views and schematics. American-Standard, Ross Heat Exchanger Div, Buffalo 5.

Circle 58, Reader Service Card

FINE-PITCH GEARS—Brochure, 4 pp. Describes and illustrates facilities for gear blanking, gear cutting, gear train and subassembly operations. Gear dimensional pitch chart is included. Juall Gear Co Inc, 1108 Goffle Rd, Hawthorne, NJ.

Circle 59, Reader Service Card

FAN-COOLED WORM GEAR—Bulletin 5018, 4 pp. Presents features of speed reducers, with hp and torque data and dimensional information. De Laval Steam Turbine Co, Trenton 2, NJ.

Circle 60, Reader Service Card

PRESSURE TRANSDUCER – Bulletin, 4 pp. General description and applications, with specifications. Includes line drawings of standard models and pressure fittings. Ultradyne Inc, PO Box 3308, 2624 San Mateo NE, Albuquerque, NM.

Circle 61, Reader Service Card

DIGITAL VOLTMETER—Bulletin 19-24, 2 pp. Presents description of Model 402, including diagram of the circuit, specifications and price. Kin Tel, Div Cohu Electronics, 5725 Kearny Villa Rd, San Diego 12, Calif.

Circle 62, Reader Service Card

TUBELESS PHOTOELECTRIC CONTROLS—Catalog 58-1, 4 pp. Describes controls with cadmium cell sensing element, with transistor and with magnetic amplifier, including suitable light sources. Contains dimensional diagrams. Autotron Inc, Box 722V, Danville, Ill.

Circle 63, Reader Service Card

CUSHIONED COUPLINGS – Bulletin 61, 2 pp. Includes diagrams and tables on coupling for light horsepower applications to 1000 rpm. John Waldron Corp, River Rd, New Brunswick, NJ.

Circle 64, Reader Service Card

BEFORE...
Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.
AFTER...
Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

Save Money

by simplifying fastener design

Here is a simple application of a basic bolt making principle which is affecting substantial savings for a number of manufacturers.

These savings, resulting from simplified design, are realized in every step of the operation from lower first cost of the fasteners through inventory to final assembly. Totalled, they are well worth while.

There are many other basic principles . . . often overlooked in designing and specifying fasteners, which are of importance cost-wise.

You'll find them in our new booklet, "How to specify fasteners . . . and save". Filled with drawings and charts, it makes a handy guide in designing or buying any headed parts.

If you can use a copy, write to North Tonawanda or ask a Field Representative.

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MAKING BOTH FASTENERS AND FRIENDS FOR 100 YEARS

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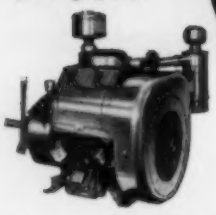
How YOU can benefit from-

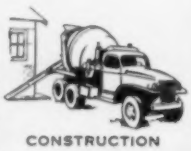


50 YEARS OF WISCONSIN ENGINE PROGRESS 1909 - 1959

AGRICULTURE

1959 is the Golden Anniversary of Wisconsin Engines. It heralds 50 years of continuous engine progress. Fifty years of engineering development and exclusive specialization in the design and manufacture of engines.

• Originally manufactured in a power range up to 200 hp., Wisconsin Engines helped to make automotive history as well as supplying dependable power for many industrial applications — service that called for the most advanced engineering.



CONSTRUCTION

• Heavy-duty design and construction and High Torque performance have been traditional features of *all* Wisconsin Engines. You get longer life from Wisconsin Engines and lowest cost maintenance.

RAILWAY

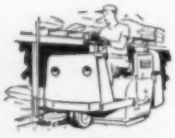
• Today the Wisconsin line comprises the most complete line of Heavy-Duty Air-Cooled Engines in the industry. They are supplied in 4-cycle single cylinder, 2-cylinder and V-type 4-cylinder models in a complete power range from 3 to 56 hp. There is a Wisconsin Engine of the right size and type to fit the job and the machine.

MATERIALS HANDLING

• Every Wisconsin Air-Cooled Engine is designed for heavy-duty service under all climatic conditions from low sub-zero to 140° F. You get the *Most Engine* for your money for MOST HP. HOURS of service.

OIL FIELD

• For 1959 Wisconsin has available a complete line of factory-built LPG Engines (including conversion kits for field installation on Wisconsin gasoline engines). In addition, we offer a new line of heavy-duty, quality-built Vertical Shaft Engines, from 3 to 7 hp.



INDUSTRIAL SERVICE

• More than 2000 convenient Wisconsin Authorized Service Stations stand ready to provide expert servicing and factory-built parts for all Wisconsin Engines.

Constructive experience is a priceless asset. The benefits to the manufacturer, distributor and user of power equipment are many. You are best served in all respects when you specify "WISCONSIN ENGINES" . . . *for better service, low-cost maintenance, trouble-free operation and long engine life.* Write for engine bulletin S-237.

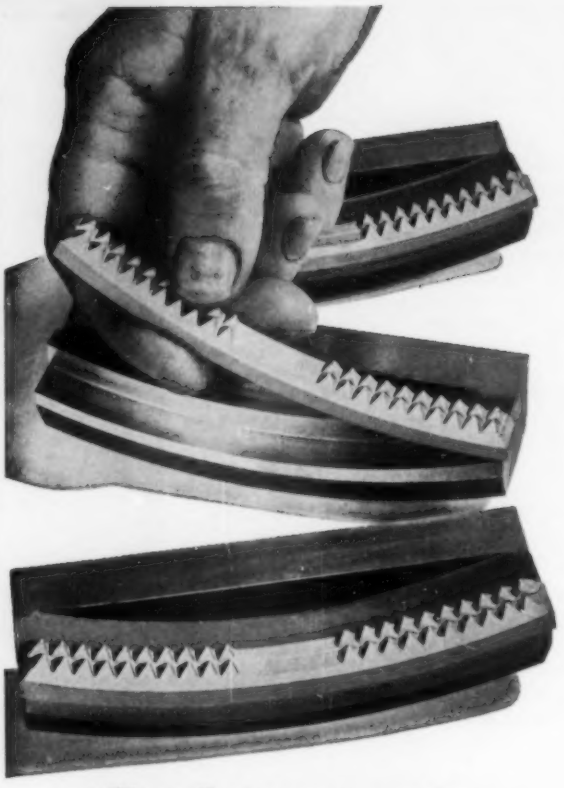
MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A8-6239-½V (A2)



Colmonoy Castings INCREASE Chuck Jaw Life

Castings made of Colmonoy hard-facing alloys are being built into many products at points of extreme wear. They prolong the life of such products many times over.

The chuck jaws shown above are designed using castings of Colmonoy No. 5, silver brazed in place. The benefits: ten weeks of service instead of three, and then easy replacement of the worn insert instead of rebuilding the jaw itself.

Investigate Colmonoy castings. Provide your products (and production equipment) with two, three, or even thirty times longer life, and at modest cost.

Submit part drawings and a description of the wear encountered for a specific recommendation. Request Hard-Facing Manual No. 79.

HARD-FACING & BRAZING ALLOYS

WALL COLMONOY CORP.

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DESIGN ABSTRACTS

1958 ASME Annual Meeting, Nov 30-Dec 5

For copies of papers: ASME, 20 W 39th St, New York 18

Spur Gears Made of Nylon

A method of calculating load-carrying capacity of gears made of Zytel resin is described. Design recommendations are included and use of nylon gears in a helical-gear speed reducer is discussed.

"Design of Spur Gears of Zytel Nylon Resin," Hall and Alvord, University of Michigan, ASME paper 58-A-209.

Lateral Vibrations in Reciprocating Machinery

Application of periodic torque to shafts driving overhung mass in rotating electrical, mechanical and hydraulic machinery tends to excite lateral vibration or "whirl." When torsional and lateral natural frequencies are close to each other, torque tending to excite harmonic order of natural frequency will also excite lateral natural frequency.

Equations are given for preliminary calculation of torsional natural frequency, torque-variation frequency and lateral natural frequency. With such data, shaft and flywheel sizes can be chosen so that frequencies can be adequately separated.

"Lateral Vibrations in Reciprocating Machinery," C. M. Lowell, Worthington Corp, ASME paper 59-A-79.

High-range Plasticity of Metals

A "high range" of plastic metal-working procedures (primarily compressive in nature) beyond point of normal tensile failure is described. Distinguished by steeper or more rapid rate of work-hardening. A testing technique designed to obtain physical properties obtained in this procedure is described, together with its application to a rocket motor body application.

"High-rang- Plasticity of Metals Beyond Normal Wo ardening," E. V. Crane, W. S. Wagner, E. . liss Co, ASME paper 58-A-132.

Gas-turbine Progress Report

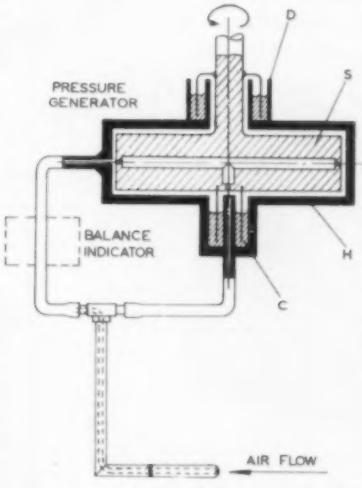
Papers by qualified persons discuss materials, cooling, fuels, cycle components, compound piston-and-turbine engines, aviation, rocket turbines, automotive, railroad, marine, industrial and central station, nuclear considerations for direct-cycle, gas-cooled reactors and gas turbine type of prime mover. This is the first progress report on this field in 6 years.

"Gas Turbine Progress Report," Sawyer, Herbenar, Esgar, Foster, Martinuzzi, London, Lancaster, Bates, Schwartz, Broadley, Simpson, Skrotski, Godwin, Dennison and others. ASME paper 58-A-46, A through M.

Centrifugal Micromanometer

A micromanometer has been developed for measuring small pressure differences of 25 mm to 5 x 10^{-3} mm water gage, with errors of less than 1%. Robustly constructed and easily transported, the instrument can be applied to measuring air speeds in moderately unsteady flow and as a calibrating standard for other manometers.

Pressure generator is operated by



centrifugal forces acting on a number of radial air columns, in a rotating disk (S). Disk is enclosed in a stationary, air-tight housing (H), and mercury seal (D) is provided where driving shaft of disk enters housing. Similar seal (C) transmits static pressure at disk center to tap on housing and also prevents internal circulation of air.

"Centrifugal Manometer," J. F. Kemp, S. African Council for Scientific and Industrial Research, ASME paper 58-A-111.

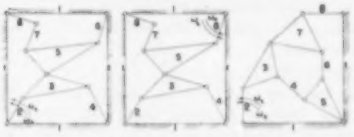
Machinability of Metals

Experiments indicate that chip formation is closely related to ratio of shearing strain to shearing stress, near the fracture point of shearing test curve of metal. The larger the ratio, the poorer the machinability. Contains some highly informative curves.

"Study of Machinability of Metals," H. Takeyuma, E. Usui, Government Mechanical Laboratory, Tokyo. ASME paper 58-A-161.

Complex Kinematic Chains

Highly complex kinematic chains can be analyzed by use of simple vector equations employing influence coefficients. All variables but one are sequentially set at zero, with appropriate constraints relaxed to maintain mobility. Analysis of velocities and



From left: driver at (2), first-order complexity; center, driver at (6), second-order complexity; right, driver at (2), higher order complexity.

accelerations for these simpler mechanisms yields influence coefficients of related but more complex mechanisms.

"Analysis of Complex Kinematic Chains with Influence Coefficient," J. Modrey, Union College, ASME paper 58-A-74.

Designing to Reduce Downtime

Machine-tool designer tells how downtime can be controlled by reducing time and money for maintenance. Three criteria by which all designs should be evaluated are discussed: (1) simplicity; (2) interchangeability; (3) flexibility. Examples from the author's own experience are given.

"Designing to Reduce Downtime," D. I. Dumond, Cross Co, ASME paper 58-A-131.

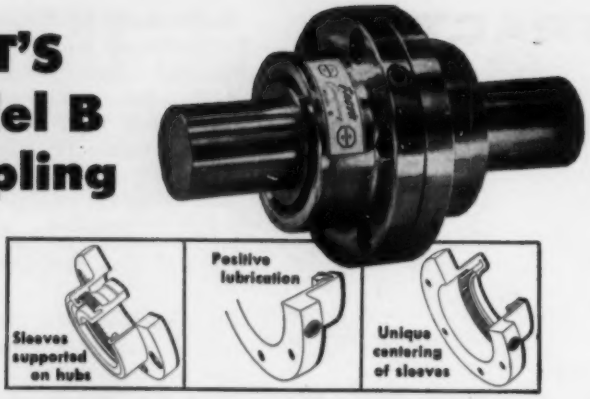
Maximum Strain Energy

A new theorem for elastic structures obeying Hooke's law is proved and enunciated: If strain energy can be expressed in terms of given external loads and positions of points constrained to have no displacement, then the expression will have a maximum value when positions are such to make constraining forces zero.

"A Theory of Maximum Strain Energy," E. H. Brown, Imperial College of Science and Technology, London, ASME paper 58-A-40.

Additional ASME Annual Meeting papers were abstracted in our Dec 29 issue. Others will appear in Jan 19 Design issue.

FAST'S Model B Coupling



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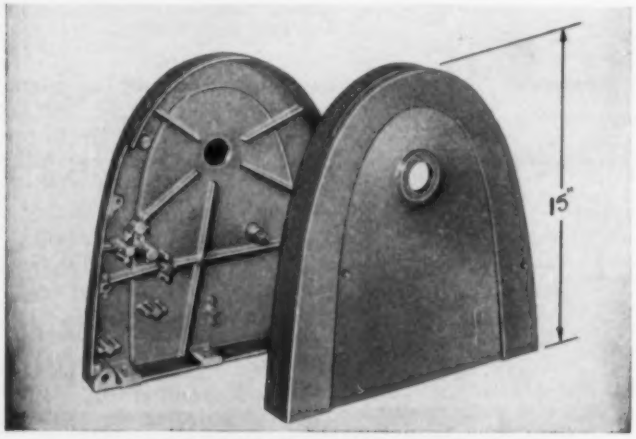

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NEW BOOKS

Steel Butt-welding Fittings

American Standard B16.9-1958. ASME, 29 W 39th St, New York 18. Paperbound, 8½ x 11, 14 pp. $1.50.

All pipe fittings which are intended to be welded into place are included in this standard. It lists dimensions, tolerances, and markings for cast fittings as well as those made of pipe, tubing, plate or forgings. This new edition includes 22 in. sizes and complete dimensions for tees of 14 in. and larger.

Metrical Relations Among Dimensions of Head and Face

CHURCHILL AND TRUETT, *Antioch College. (PB 131480)—Available from Office of Technical Service, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 127 pp. $3.50*

Correlation data for the head and face dimensions of two groups of USAF personnel are presented. These data extend the useful information about these dimensions into the areas in which two or more dimensions are considered simultaneously. Forty-one dimensions of flying personnel, based on a sample of over 4000, and six dimensions of WAF trainees, based on a sample of 852, are reported. In addition to a presentation of the data, the report discusses the utility of correlation statistics in the design of personal equipment and describes the procedures used in obtaining these data.

Electricity and Magnetism

J NEWTON. *Philosophical Library Inc. 15 E 40th St, New York 16. 513 pp, 5½ x 7¾. $10.*

Apart from two introductory chapters on electrostatics and magnetism, this book starts with a study of current electricity. It avoids placing undue emphasis on electrostatics and magnetism, the detailed consideration of these being deferred until later. The many fundamental, but often abstract, concepts which are met within a study of electricity are explained.

Information of a more technical character has been included, where appropriate, to assist the reader to

(Continued on page 96)

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operate in ANY position... provide dependable starting...

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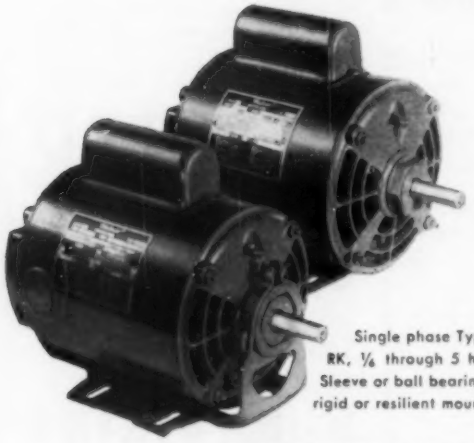

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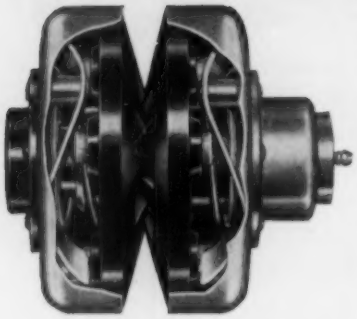

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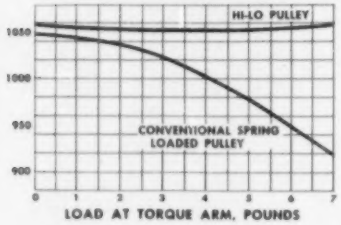

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appreciate the practical aspects of electrical science. There are also chapters on magnetic properties of materials, terrestial magnetism, thermoelectricity, an introduction to physics of the atom.

History of Mathematics

JOSEPH E HOFMAN. *Philosophical Library Inc, 15 E 40th St, New York 16. 132 pp, 5½ x 8¼. $4.75.*

Professor Hofman connects the progress of mathematics with the rise of intellectual attitudes and increasingly complex practical demands. In a wealth of detail he explores the numbers systems and methods of ancient peoples, the role of the great translators of the Middle Ages, the problems and tensions of the Scholastic period.

Numerous works of Renaissance and early Baroque mathematicians are discussed, emphasizing developments which helped to pave the way for modern concepts. The book limits itself primarily to the period of Aristotle's influence, which largely came to an end in the 17th century.

Air Force Materials Research and Development Program

HELEN E HINES. *WADC Technical Report 53-373, Supplement 4. Available from Office of Technical Services, Dept of Commerce, Washington 25, DC. Paperbound, 8½ x 11, 180 pp, $4.75.*

Abstracts of 270 technical reports prepared for Wright Air Development Center during period from July 1956

(Continued on page 97)

"He fits the definition of genius allright—has an infinite capacity for giving pains!"

WHY

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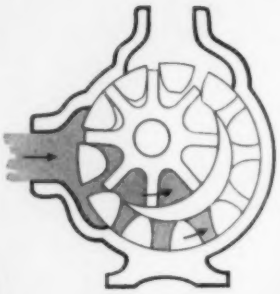
BETTER?



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they are Mechanically Superior

The Viking "gear-within-a-gear" pumping principle makes liquids flow into and through the pump, changing direction ever so slightly until liquids are trapped. This action cuts turbulence, foaming, cavitation and power consumption to a minimum. As a result, liquids are delivered in a smooth, positive flow . . . free of aeration.

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to June 1957 are included in this review. The reports cover research on many materials including structural adhesives, fur, metals, ceramics, plastics, textiles, transparent materials and many others. Included with each abstract, is name of investigator, contractor, summary of tests made, and results obtained.

Psychological Stress as a Theoretical Concept

W DEAN CHILES, Aero Medical Laboratory. (PB 131616)—Available from Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 16 pp. 75¢.

An examination of some typical treatments of psychological stress is carried out in this paper. The approach of construing stress in analogy to physical and physiological concepts is rejected since these approaches have not led to quantitative insights into the action of stress with respect to human behavior. A systematic approach, based on the presentation of J. S. Brown and I. E. Farber, is suggested along with the framework for the quantitative evaluation of psychological stress as a theoretical concept. Some of the implications of this approach with respect to performance variables are discussed.

Plain Washers

American Standard B27.2-1958. ASME, 29 W 39th St, New York 18. Paperbound, 8½ x 11, 10 pp, $1.

Included in this revised standard are type B washers which have more rigidly controlled tolerance on all dimensions than type A. They are used where clearance between parts must be closely controlled.

Direction-of-Knob-Turn Stereotypes

JAMES V BRADLEY, Aero Medical Laboratory. (PB 131612). Available from Office of Technical Services, Dept of Commerce, Washington 25, DC. 8⅜ x 10⅝, 11 pp. 50¢.

This report is based on a study in which right-handed subjects were asked to grasp a knob and turn it so as to effect a specified change in the intensity of a light mounted just above it. Equal numbers of subjects were asked to increase and to decrease the brightness of the light, the request being phrased in a variety of ways. Two significant tendencies were found.

(Continued on page 99)

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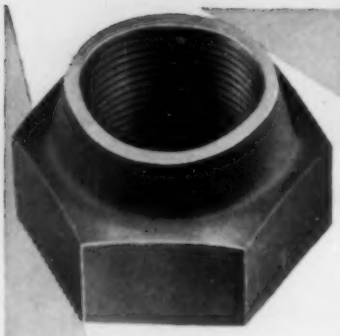

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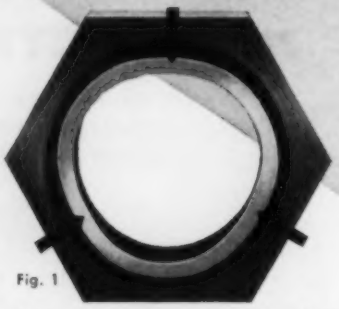

Fig. 1

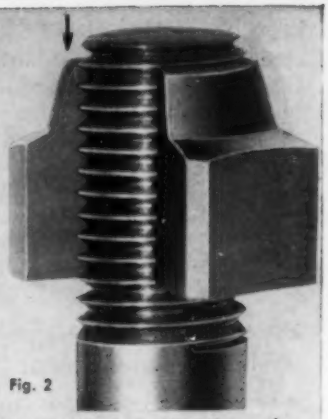

Fig. 2

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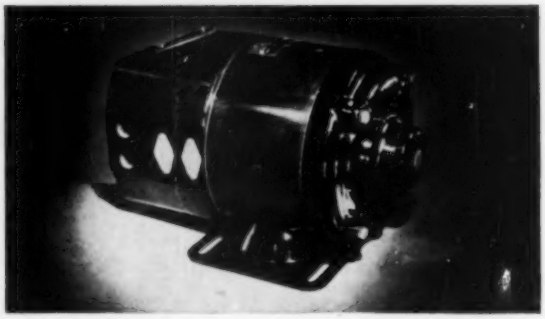

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First, 73.3% of the subjects turned the knob clockwise to increase or counterclockwise to decrease the brightness of the light. This tendency was strongest when an increase was required and when the function to be controlled was phrased in positive terms (as "brightness" rather than "dimness"). It was not significantly dependent upon the use of the words "increase" or "decrease" or upon the sex of the operator. Other experiments indicate that these results are contingent upon the use of a display which presents changes in information without visible movement.

Second, 62.5% of all subjects turned the knob clockwise. This general turn-clockwise tendency was found to persist among an additional set of right-handed subjects when the light was covered up and the subject was asked simply to turn the knob; among left-handed subjects (used only in this condition) the tendency to turn clockwise was not statistically significant.

Current Reprints

While the supply lasts, single copies of the following reprints are obtainable by using the Reader Service Card.

Engineer Salary Surveys
Engineers Joint Council says engineer salaries are up 13% since 1956. GE reports affect of higher living costs. Jan 5 *Circle E 59*

Mixed-flow Impellers
When air pressure requirements are too high for axial and too low for centrifugal fans. Jan 5 *Circle E 58*

Carpet Plotting for Hi-temp Data
Data sheet shows interaction of stress, strain and temperature. Jan 5 *Circle E 57*

Gear Standards
Proposed all-inclusive standard for spur and helical, for both instrument and power service. Dec 22, '58 *Circle E 56*

Foreign Patents
Why get them? Six steps to follow for profitable licensing. Dec 15, '58 *Circle E 55*

Tired Metal
Why have fatigue problems when you can do without them? Six solutions. Dec 1, '58 *Circle E 54*

Linkage Joints
Discussion of motions and factors leading to better joints. Dec 8, '58 *Circle E 53*

(Continued on page 101)

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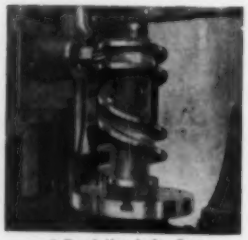

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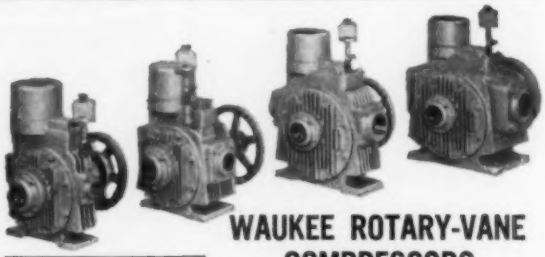

WAUKEE ROTARY-VANE COMPRESSORS

with built-in pressure regulator 400 to 6000 CFH at 1 to 3 psi

CAPACITY TABLE			
Model	CFH	Approx. RPM	Motor Size
B	400	650	⅓
C	600	700	½
D	750	850	½
H	1000	750	½
J	1250	850	¾
E	1500	1050	1
K	2000	750	1
L	2500	900	1½
M	3000	1100	1½
P	4000	700	2
T	5000	850	2
V	6000	1000	3

The Waukee Compressor supplies a steady flow of pulsation-free air or gas mixtures at pressures of 1, 2, or 3 psi. Featuring air cooling, rotary-vane construction, and a built-in automatic by-pass regulator, the Waukee Compressor is smooth, quiet and dependable. Also available for vacuum application.

Whether for OEM or replacement use, the Waukee Compressor provides a neat, sturdy, compact installation. Its rotary-vane design has few moving parts; no metal-to-metal contacts. Ball bearings are permanently lubricated with silicone grease. This simple construction means that any good mechanic can service a Waukee Compressor.

Waukee Compressor: shows rotor and blades; automatic by-pass regulator piston and diaphragm assembly.

For complete specifications, write for Bulletin 430.

Waukee ENGINEERING CO.

5145 N. 35th St. • Milwaukee 9, Wis.

makers of Waukee gas Flo-Meters • Mixers • Washers

CIRCLE 155 READER SERVICE CARD

CIRCLE 156 READER SERVICE CARD

Current Reprints .....continued

Swivel Joints

These basics will reduce trial-and-error in design. Dec 8, '58 *Circle E 52*

Porcelain Enamel

New look at wide selection of colors and textured surfaces available. Chart describes enameling processes. Nov 24, '58 *Circle E 51*

Relays

Money-saving guide and 17 questions that help avoid overdesign. Nov 24, '58 *Circle E 50*

Tap the Reserve Strength in Metal

Charts and formulas for determining how far beyond the yield strength you dare go. Sep 29, '58 *Circle E 49*

Springs that Store Energy Best

How shape and material govern efficiency; table compares 13 spring shapes. Nov 10, '58 *Circle E 48*

Which Tachometer?

Selection chart matches each available method to the need. Nov 10, '58 *Circle E 47*

Microfilm

How miniaturization of records can solve administrative problems and save design time. Oct 27, '58 *Circle E 46*

Numerical Control of Machine Tools

How it works; where it's heading; covers both discrete and continuous path. Oct 27, '58 *Circle E 45*

Optical Projectors

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Three New Rigid Thermoplastics

Delrin, Lexan and Pro-fax are compared; curves and tables. Sep 29, '58 *Circle E 43*

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New area-source of light which needs no filament, arcing or activating rays. Sep 15, '58 *Circle E 41*

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Quantity	*Price per Copy*
5	$0.25
25	0.20
50	0.15
100	Write for quotation

Make checks payable to PRODUCT ENGINEERING, 330 West 42nd St., New York 36, N. Y.

". . . my name on it?"

1. Just loosen the bolts —
2. Remove ONLY ONE —
3. Pivot the Split-Flange Clamp Half, together with the "O" Ring Flange Head Coupling, around the other bolt.
4. Remove Hose Coupling!

- Eliminates costly pipe threading operations, separate union and swivel connections.
- No threads to wear or tapered seats to groove.
- Disconnect hose lines and reconnect many times without damage, or leaks.
- Flanco "O" Ring Flange Head Type Couplings are available in Pressed-On or Reusable Clamp Type, as well as Weld Type Fittings.

Write for Catalog 402

ANCHOR COUPLING CO. INC.

345 No. Fourth Street — Libertyville, Ill.
Branch Offices—Dallas, Texas—Plymouth, Michigan

CIRCLE 157 READER SERVICE CARD

NATIONAL COVERAGE

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Positions Vacant	Civil Service Opportunities	Employment Agencies
Positions Wanted	Selling Opportunities Wanted	Employment Services
Part Time Work	Selling Opportunities Offered	Labor Bureaus

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8 mm motion picture equipment engineers

An exceptional opportunity for two talented engineers to join us as project leaders in the photographic industry's most aggressive new products program. Must have degree in Engineering and at least five years' experience in the design or production of 8mm Movie Cameras and Projectors.

For information about these opportunities, write to our Employment Manager giving work experience, age, education, and salary requirements. Interviews for qualified candidates will be arranged immediately.

argus cameras

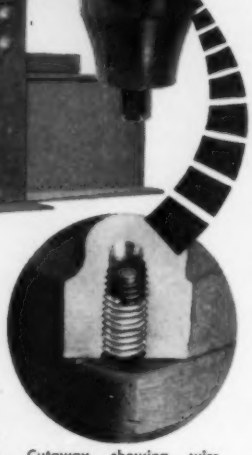
Ann Arbor, Michigan

HELI-COIL®

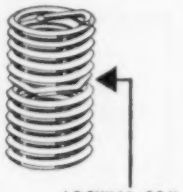
SCREW-LOCK* INSERTS
hold fasteners tight!

Designed for greater speed, safety and economy, Chicago Pneumatic Impact Wrenches exert tremendous tightening and loosening power, resist severe shock loads and rough on-the-job use.

A key feature of their construction is the use of *Heli-Coil* Screw-LOCK Inserts which lock screws within the tapped holes at vital connections. No heavy, protruding lock-nuts are required, no lock-washers. No costly, time consuming lock-wiring. And security? *Heli-Coil* Screw-LOCK Inserts meet Government specs for locking torque and vibration. The wrench is made of aluminum alloy for lightness and ease of handling, but thread stripping in this light metal is eliminated by the stainless steel Screw-LOCK Inserts.



Cutaway showing wire thread *Heli-Coil* Screw-LOCK Insert in flange seat of Chicago Pneumatic Impact Wrench.



LOCKING COIL

HELI-COIL Screw-LOCK Inserts

- positively lock screws against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling, seizing
- eliminate need for lock-nuts, lock-wiring, other supplementary locking devices
- offer high re-useability on repeated disassembly and reassembly

Screw-LOCK Inserts are available in a complete range of sizes, including the new miniature 4-40. For more information on how to make your product lighter, tighter, more compact or less costly, write

HELI-COIL CORPORATION
Shelter Rock Lane, Danbury, Connecticut

*Pat. Applied For

HELI-COIL CORPORATION
601 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.

NAME_____ TITLE_____

FIRM_____

ADDRESS_____

CITY_____ ZONE____ STATE_____ 4789

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

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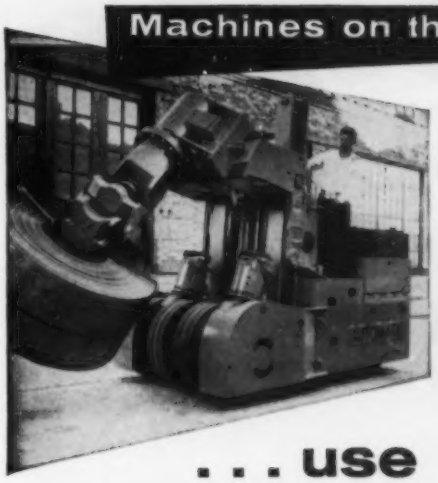


. . . use

FAIRFIELD GEARS!

POWER to operate these machines and countless others that you may see every day, travels *smoothly, efficiently, dependably* through FAIRFIELD GEARS. By specializing exclusively in "Fine Gears Made to Order", Fairfield has become one of America's largest independent producers of these parts.

If you use gears in the product you make, we believe it will pay you, as it has others, to become acquainted with FAIRFIELD—the place where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY! Fairfield's production facilities are unexcelled. *Call or Write.*

FAIRFIELD MANUFACTURING CO.

2313 South Concord Road • Lafayette, Indiana

TELEPHONE: 2-7353

A "PLUS VALUE" IN ANY PRODUCT

Gears and Differentials For FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

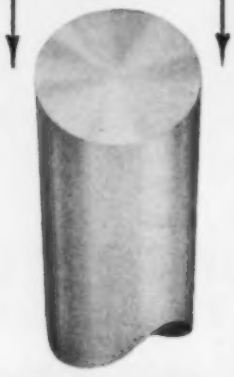
New Cap Fastener for Unthreaded Rod

PUSH OR TAP --IT'S ASSEMBLED

on plain round rods, axles, studs, rivets, pins, shafts

•

Saves cost of threading --notching--drilling for cotter pins



TYPE W PUSHNUT® FASTENERS

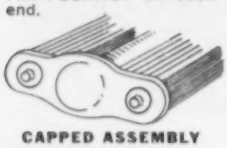
Type W PUSHNUT Fasteners are made in one piece of heavy gauge tempered spring steel, with a special locking action that grips unthreaded rod and exerts powerful resistance to removal from 1/10 to 1/2 ton. On knocked down assemblies they are easily applied by tapping with a hammer. In factory assembly, readily applied by air hammer, press, or jigs for multiple assembly.

- Low in cost
- Easy, speedy assembly
- Rugged holding power
- Decorative, smooth, neat appearance
- Sturdy construction --will not dent or deform
- Always assemble in line --will not cock or misalign
- Variety of finishes
- Sizes for 3/16", 1/4", 5/16", 3/8", 7/16" and 1/2" dia.

TYPICAL APPLICATIONS

HINGE ACTION
Rivet: Headed on one end, with PUSHNUT on other. Pin: PUSHNUT on each end.

PIVOT ACTION
Retainer on bell cranks or levers on integral studs or shafts.



CAPPED ASSEMBLY
Smooth, attractive assembly of parts not required or desired to be held under heavy tension or pressure.

HUB CAP WHEEL RETAINER
Attractive, reliable fastening of wheels on axles of all kinds of vehicles.

Write for free samples, stating type, size and intended application.

THE PALNUT COMPANY, 65 Glen Road, Mountainside, N. J.
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

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F. J. Eberle, Business Mgr.

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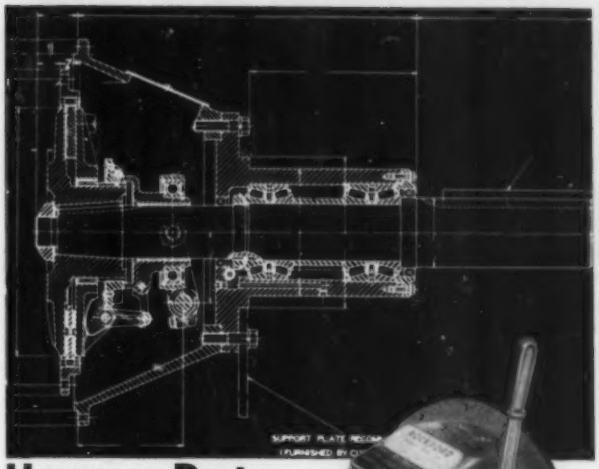
ROCKFORD



Heavy-Duty LONG LIFE

POWER TAKE-OFF

Provides

THESE EXCLUSIVE ADVANTAGES

Designed to meet the needs of Oil Field and other rugged service—this ROCKFORD Extra Heavy-Duty POWER TAKE-OFF

- Eliminates the Pilot Bearing
- Release and Main Bearings are lubricated for one year
- Main Bearings are 40,000 hour type
- Handles 5,000 pound Belt Loads
- Out-Board Bearings and Flexible Couplings eliminated
- Furnished with Single or Double Plate, Organic or Marlife® faced Gear tooth Type Clutches

Insure longer work life and reduce down-time with this NEW extra heavy-duty ROCKFORD POWER TAKE-OFF.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

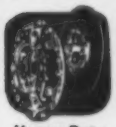
ROCKFORD Clutch Division BORG-WARNER

209 Catherine St., Rockford, Ill., U.S.A.

Export Sales: Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

Small Spring Loaded

Automotive Spring Loaded


Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

ROCKFORD B-W BORG-WARNER

CLUTCHES

the spirit of '76...

THE SPIRIT OF '76 . . . exemplifying strength —dependability—determination to move forward through the years.

Wyman-Gordon enters its 76th year still forging ahead with new forging techniques—still meeting the challenge of the seemingly impossible in this age of power and speed on the ground—in the air—and in outer space.

It is a far cry from the modest beginning in 1883 to the forging industry's most modern testing and research facilities in the extensive laboratories of Wyman-Gordon today—assurance of the ultimate in forging quality.

From the high wheel bicycle through the "horseless carriage" days to the "Mach era" of aircraft and space vehicles, Wyman-Gordon has marched under the standard of "The Greatest Name in Forging."

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN

buy your horsepower at the output shaft

Speed reducer problems involve more than just gear ratios. Horsepower, torque, overhung loads and duty cycle are considerations that require performance matching of motor and reducer. When you specify Master Gearmotors you eliminate dual responsibility for overall performance.

Master Gearmotors are packaged components, engineered to meet your requirements from line voltage to keyway dimensions. Motor and reducer are built as a single, rigidly aligned unit. These compact drives offer maximum efficiency and durability at minimum cost.

You can reduce engineering and assembly expenses by giving Master the responsibility for the entire power package. With Master Gearmotors you buy your horsepower where you need it, at the output shaft.

Vertical and horizontal, right angle and parallel shaft, worm, helical and herringbone gearing—⅛ thru 125 hp.

Product of Master Electric Division of Reliance Electric and Engineering Company, manufacturers of a-c. motors, Reeves Drives, V★S Drives, Super "T", D-c. Motors, generators, controls, and engineered drive systems. E1609

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 301A, CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in Principal Cities

MASTER R REEVES

Name your bearing needs...we'll meet 'em pronto from 30 types, 10,247 sizes

TIME and time again, machinery makers come to the Timken Company for help with some special bearing application problem. One they think hasn't been solved before. And time after time, from our 30 types and 10,247 sizes of Timken® tapered roller bearings, we've come up with the bearing design to do the job and at minimum cost.

It's no accident that we can help out so often. In sixty years of helping machinery builders with bearing problems, we've engineered and produced the world's largest selection of tapered roller bearings. And we've constantly improved our designs. The answers to thousands of bearing application problems are already in our files. Ready and available to help you.

And machine users get the same swift service if they ever need a replacement Timken bearing. Even for old machines, they can almost always count on immediate delivery of Timken bearings for replacement.

Why not call on our engineers for help whenever you have a bearing application problem or requirement? Timken is your No. 1 bearing value. Wherever wheels and shafts turn, Timken bearings eliminate friction, cutting wear and maintenance to a minimum. Specify bearings trade-marked "Timken" for the machines you buy or build. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN TAPERED ROLLER BEARINGS ROLL THE LOAD

TRADE-MARK REG. U. S. PAT. OFF.